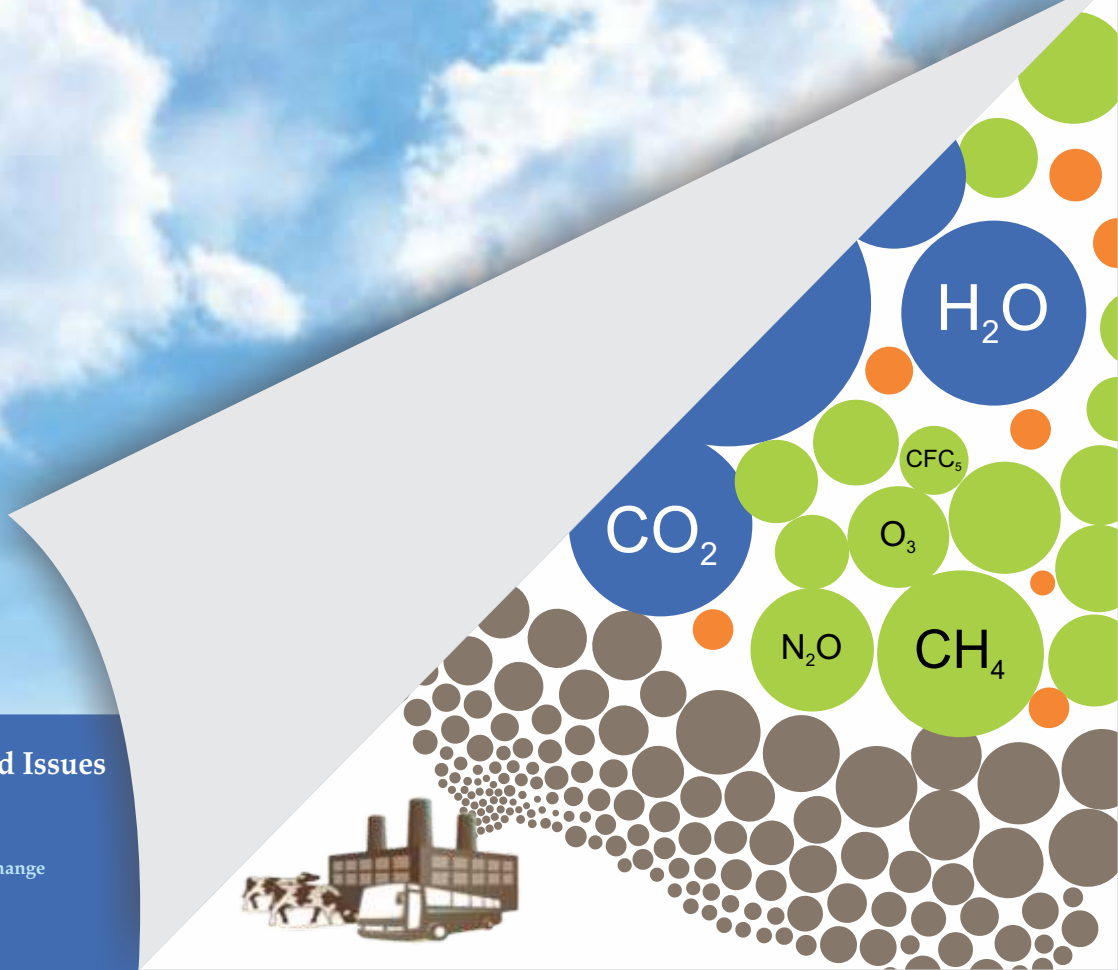
Punjab ENVIS Newsletter

Vol 13, No. 4
ISSN No.2347-2960

Climate Change



Status of Environment & Related Issues

www.punenvis.nic.in

Supported By
Ministry of Environment, Forests & Climate Change
Government of India

EDITORIAL

The Earth is the only planet in the solar system known to habour life, and the crucial factor responsible for this is its conducive climate. Over the long-term the earth's climate varies naturally. However, today's climatic changes are unfolding at an exceedingly rapid rate due to the anthropogenic Green House Gas emissions. Carbon dioxide along with other greenhouse gases enhanced the natural greenhouse affect which resulted in adverse Climate Changes in today's world.

As per 5th Assessment Report of the Intergovernmental Panel on Climate Change, the temperature of earth is projected to rise from 0.3°C-4.8°C by the end of the century (2081-2100) relative to 1986-2005 under all assessed emission scenarios. This warming would be much larger and much more rapid than any temperature change experienced over at least the last 10,000 years. It would have significant impacts on human society and the natural environment. These adverse changes in climate are now inevitable due to historical Green House Gas emissions and the risks of pervasive and irreversible impacts of Climate Change are expected to increase. They could, however, be reduced through abatement and adaptation measures, building on mitigation actions at global and local levels. Thus, the two most important strategies to respond to the affects of Climate Change are adaptation which involves taking action to help communities & ecosystems cope with changing climate conditions and mitigation which is based on action to limit net emissions of greenhouse gases.

In view of above, the Governments all around the world are incessantly setting course for ambitious actions to combat Climate Change. Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement on December 12, 2015 in Paris, charting a fundamentally new course in the two-decade-old global climate effort. The Paris Agreement for the first time brought 195 nations into a common cause based on their historic, current and future responsibilities towards a low carbon, resilient and sustainable future. The universal agreement's main aim is to keep a global temperature rise this century well below 20° C and to drive efforts to limit the temperature increase even further to 1.5° C above pre-industrial levels.

Through this Newsletter issue Environment Information System (ENVIS) Centre, Punjab State Council for Science & Technology (PSCST) attempts to help people understand about Climate Change, its causes, impacts and future projections. It summarizes the major initiatives taken at global and national level to combat Climate Change. The article also highlights the key state specific Climate Change related actions undertaken by Government of Punjab namely, Preparation of State Action Plan on Climate Change, Constitution of State Steering Committee and Establishment of Climate Change Knowledge Centre. Further, it lists the ongoing major Climate Change Projects such as Climate resilient Livestock Production System, Gainful utilization of Paddy Straw to benefit Environment and Sector specific Capacity Building Programs.

- Editors

Published by

Punjab ENVIS Centre
Punjab State Council for
Science & Technology,
Chandigarh, INDIA

Sponsored by

Ministry of Environment, Forests &
Climate Change, Government of India

Contact Us

Punjab ENVIS Centre
Punjab State Council for
Science & Technology
MGSIPA Complex, Institutional Area,
Sector 26, Chandigarh - 160 019
Phones : 0172-2792325, 2795001
Fax : 0172-2793143
Email : pun@envis.nic.in

ENVIS Centre, PSCST is a partner in Regional Centre of Expertise (RCE) Chandigarh, a global network on Education for Sustainable Development (ESD) of United Nations University - Institute of Advanced studies, Japan. This article on Climate Change is an initiative to document the Climate Change related significant information. It is hoped that this publication will serve as a useful resource & empower readers to make smart & sustainable choices for future.

Introduction

Climate is defined as the average weather conditions of a certain region, including temperature, rainfall, and wind. The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The earth's climate is most affected by latitude, the tilt of the Earth's axis, the movements of the Earth's wind belts, and the difference in temperatures of land & sea, and topography.

The Change in Climate or Climate Change is often interchangeably referred as Global warming but there is a difference between the two as given in Box 1. Climate Change is a large-scale, long-term shift in the planet's weather patterns or average temperatures. Earth has had tropical climates and ice ages many times in its 4.5 billion years. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather. Climate Change can be viewed as consisting of two components, one of which is human (i.e., anthropogenic) in origin and coincides in timing with the industrial period of the past two centuries, and the other of which is natural and has played a role in both past and current climate variability.

Human or anthropogenic activities since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, due to increased emissions of Carbon dioxide (Co_2), Methane (CH_4), Tropospheric ozone (O_3), Chloro - Fluoro Carbons (CFCs) and Nitrous oxide (N_2O) resulting in enhanced Green House effect (Box 2). They are causing global warming, which in turn is causing Climate Change.

Climate Change is unequivocal and affects all continents and the changes are seen since the mid 20th century and have been "unprecedented over decades to millennia.

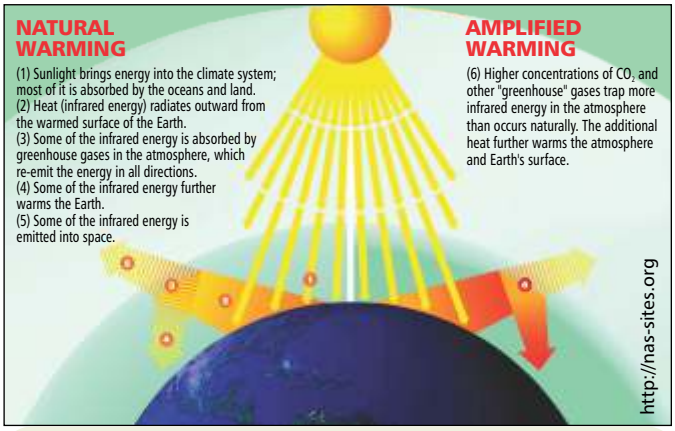
Box 1: Global Warming & Climate Change

Global warming is the increase in Earth's average surface temperature due to rising levels of Green House Gases. Thus it is simply one of the attributes of Climate Change. It generally refers to the anthropogenic component of Climate Change alone, and only the surface warming associated with it.

Further the 'Climate Change' refers to the changes in the global climate which result from the increasing average global temperature. For example, changes in precipitation patterns, increased prevalence of droughts, heat waves, and other extreme weather, etc

Source : National Aeronautics and Space Administration

Box 2: Green House Gases and Green House Effect



The earth's atmosphere traps solar radiation and is mediated by the presence of certain atmospheric gases, (such as carbon dioxide (CO_2), water vapour, ozone (O_3), methane (CH_4) and (N_2O) commonly known as Green House Gases (GHGs) that allow incoming sunlight to pass through but absorb the heat radiated back from the earth's surface. Thus, GHGs naturally keep the Earth warms by absorbing energy and slowing the rate at which the energy escapes to space and keep the Earth's surface warm. This phenomenon is termed as Greenhouse effect. Without the natural greenhouse effect, the temperature would be much colder than it is. These gases act as a thermal blanket for the planet, warming the surface to a life-supporting average of 59º Fahrenheit (15º Celcius). The recent rapid increase in greenhouse gases has resulted in a thickening of the atmosphere. The thicker atmosphere traps more solar radiation and in turn, raises the global temperature. Human activities, especially burning fossil fuels, are increasing the concentrations of many of these gases and amplifying the natural greenhouse effect.

Different greenhouse gases can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy known as "radiative efficiency", and in period of their stay in the atmosphere, also known as their "lifetime".

Gas	Main Source	Heat Trapping Effectiveness relative to CO_2	Overall contribution to global warming
H_2O	Evaporation of Oceans and lakes	0.1	--
CO_2	Combustion of fossil fuels and biomass	1	50%
CH_4	Anaerobic decay of organic matter caused by intensive farming	30	18%
N_2O	Artificial fertilisers and Combustion of biomass and hydrocarbons	1	50%
O_2	Secondary pollutant in photochemical smog	2000	12%
CFCs	Refrigerants, propellants, foaming agents, solvents	10000	14%

Source: climatechangenationalforum.org

The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.

Scientific understanding of global warming is increasing. The Intergovernmental Panel on Climate Change (IPCC) reported in 2014 that scientists were more than 95% certain that global warming is mostly being caused by increasing concentrations of greenhouse gases (GHG) and other human (anthropogenic) activities. As per 5th Assessment Report of IPCC, the temperature of earth is projected to rise from 0.3°C - 4.8°C by the end of the century (2081-2100) relative to 1986-2005 under all assessed emission scenarios (Source: http://ar5-syr.ipcc.ch)

Evidences of Climate Change

Scientists have been taking widespread Earth measurements at many thousands of locations, both on the land and over the oceans which indicate the Climate patterns, changes and trends in the Global Climate System. Detecting climate trends is complicated by the fact that there are many natural variations in temperature, precipitation and other climate variables. The attributes of Climate Change rely on the information obtained from climate models (Box 3). The observed global Climate Changes and their evidences are as under (Source: AR4/5, http://www.ec.gc.ca & https://www.ipcc.ch):

1) **Global Land & Ocean Temperature Anomalies:** The data compiled by United States National Oceanic & Atmospheric Administration (NOAA) records that there were global land and ocean temperature anomalies between 1880 and 2015, relative to the 20th century average (January - December).The statistics shows that temperatures were colder than average between 1880 and 1940 and were warmer than average since the late 1970s. Further, this trend indicates that the global temperature rise over the 20th century. The graph shows that 2014 was the warmest year with temperatures at 0.74°C above average. The coldest years had been in the early 1900s with temperatures around 0.49°C below average. Thus, each of the last three decades has been successively warmer than any preceding decade since the 1850s. Further, during 2015, it has been reported that the globally-averaged land surface temperature was 2.39°F (1.33°C) above the 20th century average which was the highest among all years in the 1880-2015 record, surpassing the previous record of 2007 by 0.45°F (0.25°C). It is the largest margin by which the annual global land temperature has been broken (Fig1).

Box 3: Climate Models

Climate Models are computer programs to help scientists understand the climate system function and help to predict future Climate Change. Climate models are programs which combine atmospheric circulation, ocean circulation, atmosphere-ocean interactions, and feedback cycles to simulate climate processes They are obtained from geological evidences from borehole temperature profiles, cores removed from deep accumulations of ice, floral and faunal records, glacial and periglacial processes, stable-isotope and other analyses of sediment layers, and records of past sea levels. These models are based on a series of mathematical equations representing the basic laws of physics-laws that govern the behaviour of the atmosphere, the oceans, the land surface, and other parts of the climate system, as well as the interactions among different parts of the system.

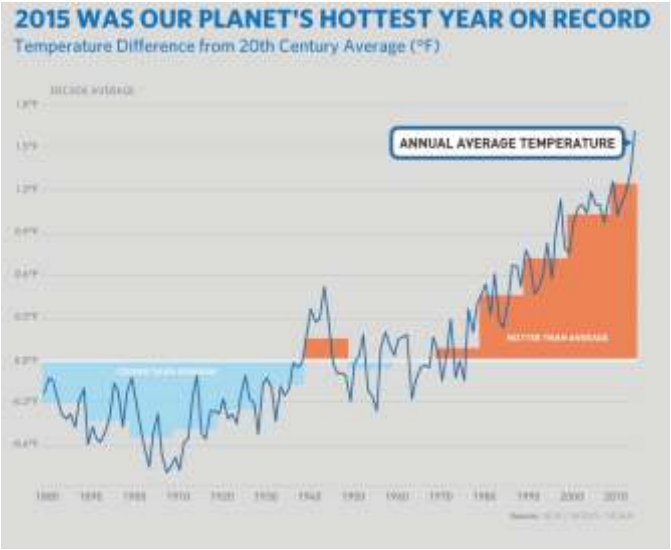
Climate models are important tools for understanding past, present, and future Climate Change. Climate models are tested against observations so that scientists can see if the models correctly simulate the actually happening in the recent or distant past. There are various types of climate models. Some focus on certain things that affect climate such as the atmosphere or the oceans. Other models are based on many factors of the atmosphere, biosphere, geosphere, hydrosphere, and cryosphere to model the entire Earth system. They take into account the interactions and feedbacks between these different parts of the planet. Some of the different types of models used for climate prediction are Hardley Centre Coupled Model Version 3 (HadCM3), Providing Regional Climates for Impacts Studies (PRECIS), Global Climate Model / General Circulation Model (GCM), Regional Circulation Model (RCM), Climate Model Inter Comparison Project (CMIP), Representative Concentration Pathways (RCP), etc.

Source : www.wmo.int & http://climateprediction.net

www.nap.edu

Source : National Academy of Sciences, 2012

Fig. 1. Changes recorded in Global Land & Ocean Temperature



Source : National Oceanic & Atmospheric Administration

2. **Indicators of a warming planet:** The major indicators determining the change in climate are temperature (land & ocean), sea level, sea ice extent, snow cover, greenhouse gases, etc. The various indicators from IPCC fifth Assessment Report (AR5) are shown in Map 1 & Map 2 and graphs at Fig 2 a-e. The details of the same are as under :

- The last three decades individually have been successively warmer than any preceding decade since 1850 as observed from the change in surface temperature and precipitation during 1951 to 2010 as depicted in Maps 1& 2. Map 1 shows observed surface temperature change from 1901 to 2012 derived from temperature trends determined by linear regression from one dataset (orange line in panel Fig 2 a). Trends have been calculated where data availability permits a robust estimate (i.e., only for grid boxes with greater than 70% complete records and more than 20% data availability in the first and last 10% of the time period). Other areas are white. Grid boxes where the trend is significant at the 10% level are indicated by a + sign. Map 2 shows trend in precipitation over land for 1901-2010 (left) and 1951-2010 (right). Bluish colours denote increasing trend while brownish colours denote decreasing trend.
- The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 [0.65 to 1.06] °C over the period 1880 to 2012 as shown in Fig 2a.
- The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia and the global mean sea level has risen about 20 cm. Fig 2 b shows global average sea level (measured in mm) from 1900 to present. Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m.

  Further, a graph at Fig 2 c shows the Arctic summer sea ice extent (measured in million square kilometers (km^2) from 1900 to present. This graph shows that amounts of ice have diminished over time, with extent ranging from over 10 million km^2 in 1990 to around 6 million km^2 in recent years. Over the period 1992 to 2011, the Greenland and Antarctic ice sheets have been losing mass, likely at a larger rate over 2002 to 2011. Glaciers have continued to shrink almost worldwide. The annual mean Arctic sea-ice extent decreased over the period 1979 to 2012, with a rate that was very likely in the range 3.5 to 4.1% per decade. Arctic sea-ice extent has decreased in every season and in every successive decade since 1979, with the most rapid decrease in decadal mean extent in summer (July to September average). It is very likely that the annual mean Antarctic sea-ice extent(February) increased in the range of 1.2 to 1.8% per decade between 1979 and 2012 Arctic and Antarctic sea ice extent. It may be due to the strong regional differences in Antarctica that the sea ice extent is increasing in some regions and decreasing in others.
- The global atmospheric concentrations of GHGs are at levels that are unprecedented in at least 800,000 years. The concentrations of CO_2, CH_4 and N_2O have all shown large increases since 1850 (40%, 150% and 20%, respectively) as shown in graph at Fig 2 d. CO_2 concentrations are increasing at the fastest at an observed decadal rate of change (2.0 ± 0.1 ppm/yr) for 2002- 2011. After almost one decade of stable CH_4 concentrations since the late 1990s, atmospheric measurements have shown renewed increases since 2007. N2O concentrations have steadily increased at a rate of 0.73 ± 0.03 ppb/yr over the last three decades.
- The greenhouse gas emission data from forestry and other land use as well as from burning of fossil fuels, cement production and flaring as shown in Fig 2 e. Cumulative emissions of CO_2 from these sources and their uncertainties are shown as bars and whiskers, respectively, on the right hand side. The global effects of the accumulation of CH_4 and N_2O emissions are shown in panel.

Map 1 & 2. Observed change in annual precipitation over land

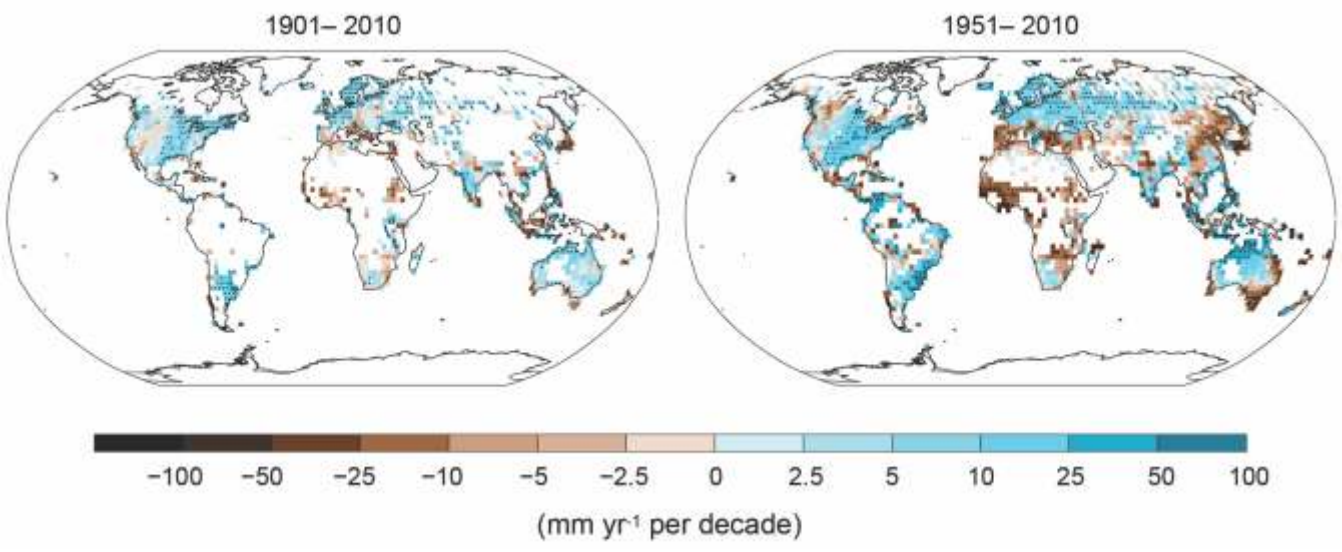
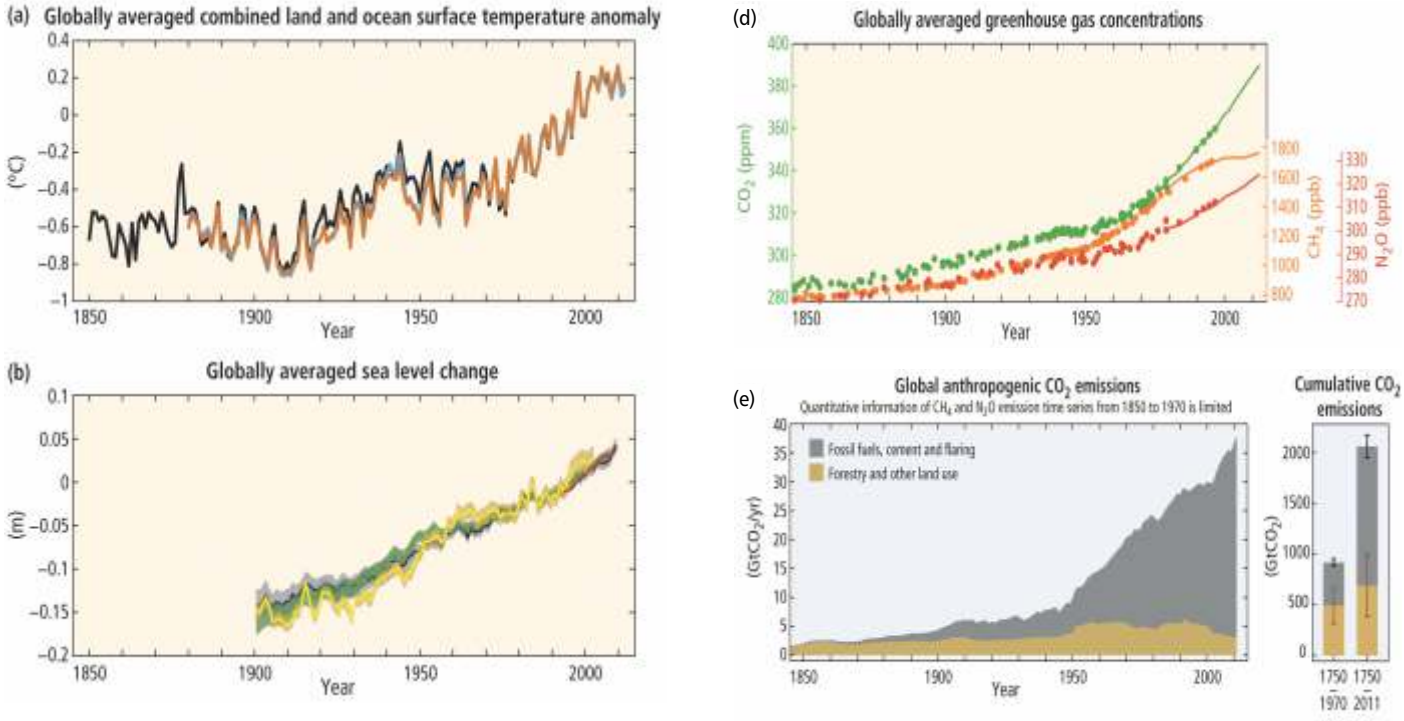
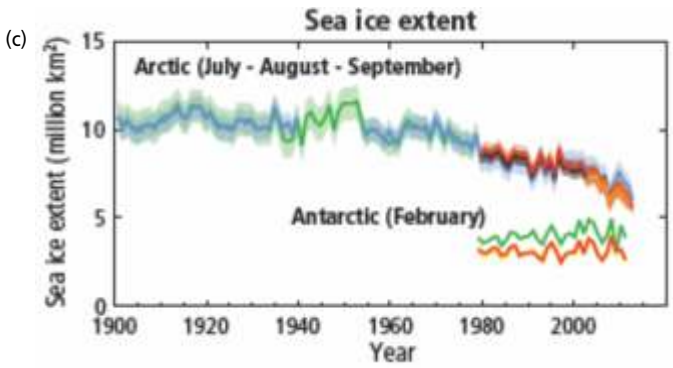


Fig. 2. Observations and other indicators of a changing global climate system





Source: IPCC

Causes of Climate Change

The earth's climate is dynamic and changes through a natural cycle. Climatologists have attempted to reconstruct past climate variations on regional and global scales, but they also try to determine the mechanisms, called forcers, that drive Climate Change. The scientists recognise two basic categories of forcers.

Natural forcers: These are recurring processes that have been around for millions of years such as changes in volcanic activity, solar output/radiation, and the Earth's orbit around the Sun, the El Nino- Southern Oscillation (Box 4). Of these, the two factors relevant on timescales of contemporary Climate Change are changes in volcanic activity and changes in solar radiation. In terms of the Earth's energy balance, these factors primarily influence the amount of incoming energy. Volcanic eruptions are episodic and have relatively short-term effects on climate. Changes in solar irradiance have contributed to climate trends over the past century but since the Industrial Revolution, the effect of additions of greenhouse gases to the atmosphere has been over 50 times that of changes in the Sun's output (http://climatechange.gc.ca).

Anthropogenic forcers: They are more recent processes caused by human activity such as the burning of fossil fuels and the conversion of land for forestry and agriculture. Since the beginning of the Industrial Revolution, these human influences on the climate system have increased substantially. In addition to other environmental impacts, these activities change the land surface and emit various substances to the atmosphere. These in turn can influence both the amount of incoming energy and the amount of outgoing energy and can have both warming and cooling effects on the climate. The overall effect of human activities since the Industrial Revolution has been a warming effect, driven primarily by emissions of GHGs and dominant amongst GHGs is CO_2. It has been emitted in vast quantities from the burning of fossil fuels and it is a very long-lived gas, which means it continues to affect the climate system during its long residence time in the atmosphere.

Box 4. El Niño and La Niña

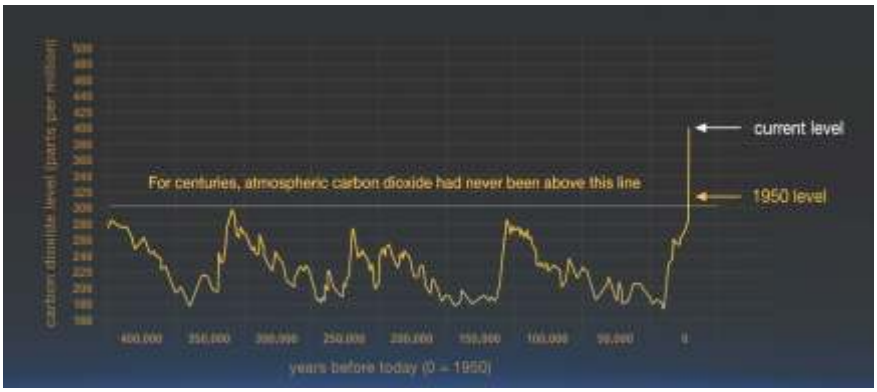
The seasonal changes in the heating and cooling of sea surface temperatures tend to follow a fairly predictable pattern. However, there are periods of unusually high levels of heating and cooling. El Niño and La Niña are terms that have been given to identify temperature variations of the Pacific Ocean between Australia and South America.

- El Niño refers to a period of rising sea surface temperatures (typically a rise in excess of 0.5 °C above the average) in the tropical eastern and central Pacific.
- La Niña refers to a period where the sea surface temperatures in the equatorial eastern and central Pacific cool well below the expected average.

The strongest pieces of evidence for Climate Change is the consistent rise in carbon dioxide (CO_2) in modern times, as measured at the Mauna Loa Observatory in Hawaii, where CO_2 has been observed since 1958. As of December 2008, the concentration of CO_2 in Earth's atmosphere was about 386 parts per million (ppm), with a steady recent growth rate of about 2 ppm per year.

The atmospheric carbon dioxide does naturally fluctuate, but it's never been has high as it is today. Current atmospheric concentrations of CO_2 are about 30% higher than they were about 150 years ago at the dawn of the industrial revolution. According to the Scripps Institution of Oceanography, ice core reconstructions going back over 400,000 years show concentrations of around 200 ppm during the ice ages and about 280 ppm during the warm interglacial periods. In other words, our current CO_2 levels are higher than they've been in at least the last 400 millenia (Fig 3).

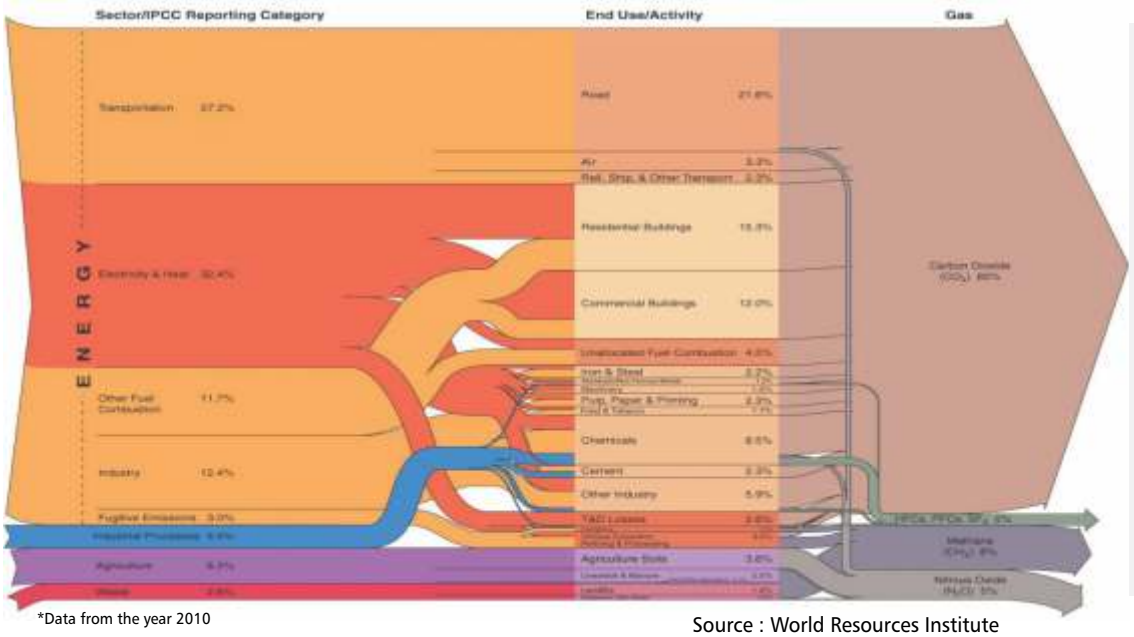
Fig. 3. Observed increase in CO_2 concentration



This graph is based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Credit: Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO_2 record.)

Source: Source: http://climate.nasa.gov

Flow Chart : World GHG Emissions



*Data from the year 2010

Source : World Resources Institute

The flow chart shows the worldwide mass flow diagram of the sources of anthropogenic greenhouse gas emissions i.e. contributed by people):

- The main gases are on the right. From top to bottom these are CO_2 CH_4, and N_2O.
- Specific end uses are in the middle, and industrial sectors are on the left, including energy, manufacturing, waste, agriculture and land use.
- The significant contributions of agriculture and land use change make up almost one third of the total inputs. The land-use change (emissions from deforestation, timber harvest, management , etc activities) represented by the green bars. The agriculture (emissions from soils, livestock manure, fertilizers, etc) is represented by the purple bar .

The fossil fuel combustion, industrial processes, agriculture, and forestry-related activities emit other substances that also act as climate forcers. Such as N_2O, are long-lived greenhouse gases like CO_2, and so contribute to long-term Climate Change. Other substances have shorter atmospheric lifetimes because they are removed fairly quickly from the atmosphere. Therefore, their effect on the climate system is similarly short-lived. Together, these short-lived climate forcers are responsible for a significant amount of current climate forcing from anthropogenic substances. Some short-lived climate forcers have a climate warming effect ('positive climate forcers') while others have a cooling effect ('negative climate forcers').

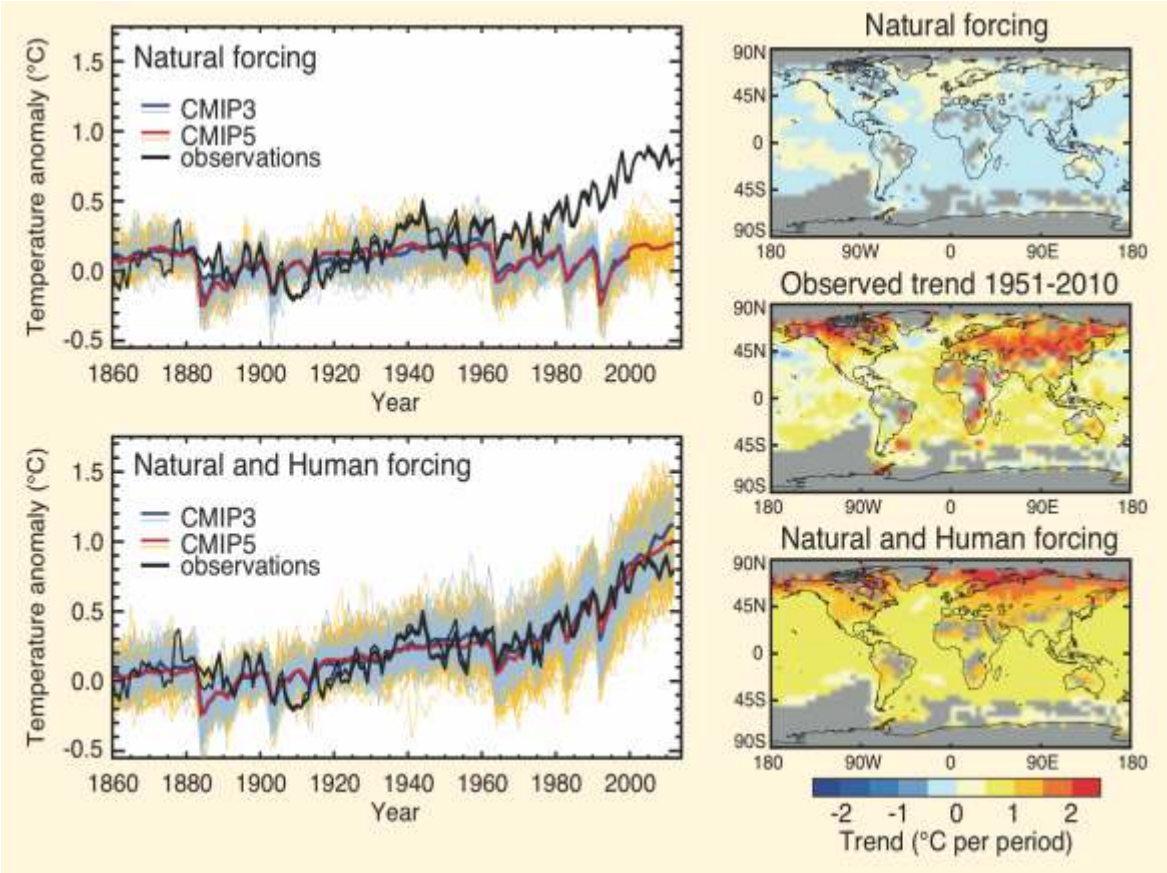
If atmospheric levels of short-lived climate forcers are continually replenished by ongoing emissions, these continue to exert a climate forcing. However, reducing emissions will quite quickly lead to reduced atmospheric levels of such substances. A number of short-lived climate forcers have climate warming effects and together are the most important contributors to the human enhancement of the greenhouse effect after CO_2. This includes CH_4 and tropospheric ozone - both greenhouse gases - and black carbon, a small solid particle formed from the incomplete combustion of carbon-based fuels (coal, oil and wood for example).

Other short-lived climate forcers have climate cooling effects, most notably sulphate aerosols. Fossil fuel combustion emits sulphur dioxide into the atmosphere (in addition to carbon dioxide) which then combines with water vapour to form tiny droplets which reflect sunlight. Sulphate aerosols remain in the atmosphere for only a few days (washing out in what is referred to as acid rain), and so do not have the same long-term effect as greenhouse gases. The cooling from sulphate aerosols in the atmosphere has, however, offset some of the warming from other substances i.e the warming experienced to date would have been even larger had it not been for elevated levels of sulphate aerosols in the atmosphere.

As mentioned before, scientists use these models to simulate the happening if humans had not modified Earth's climate i.e. the change in global temperatures if only natural factors (volcanoes, the Sun, and internal climate variability) were influencing the climate system. These "undisturbed Earth" simulations predict that, in the absence of human activities, there would have been negligible warming, or even a slight cooling, over the 20th century. When greenhouse gas emissions and other activities are included in the models, however, the resulting surface temperature changes more closely resemble the observed changes.

The climate models are able to reproduce many of the observed changes when forced with observed GHG concentrations that natural processes alone cannot explain observed warming as shown in Fig 4. It shows that the pattern of observed temperature change is significantly different than the pattern of response to natural forcings alone. The simulated response to all forcings, including human-caused forcings, provides a good match to the observed changes at the surface. The recent observed Climate Change cannot be correctly simulated without including the response to human-caused forcings, including greenhouse gases, stratospheric ozone, and aerosols. Natural causes of change are still at work in the climate system, but recent trends in temperature are largely attributable to human-caused forcing.

Fig. 4 . Global Annual-Averaged Surface Temperature Change due to Natural & Anthropogenic forcings



The top left panel in Figure shows results from two ensemble of climate models (thin blue and yellow lines) driven with just natural forcings,; ensemble average temperature changes are thick blue and red lines. Three different observed estimates are shown as black lines. The lower left panel shows simulations by the same models, but driven with both natural forcing and human-induced changes in greenhouse gases and aerosols. (Right) Spatial patterns of local surface temperature trends from 1951 to 2010. The upper panel shows the pattern of trends from a large ensemble driven with just natural forcings. The bottom panel shows trends from a corresponding ensemble of simulations driven with natural + human forcings. The middle panel shows the pattern of observed trends from surface temperature.

*CMIP means Climate Model Intercomparison Project which are the ensemble Models of the IPCC to gather & review global climate models. CMIP3 & CMIP5 models are used in 4th & 5th IPCC Assessment Reports.

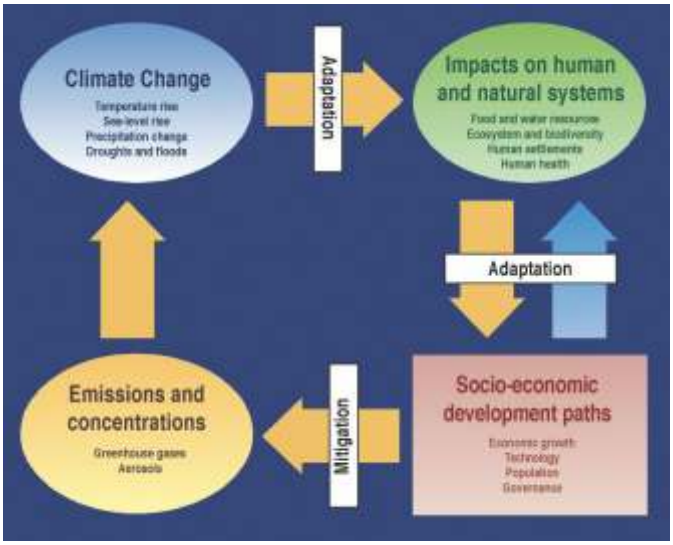
Source: IPCC

Impacts of Climate Change

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed Climate Change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate. There are three major categories of impacts as per IPCC's AR5 which are detailed as under:

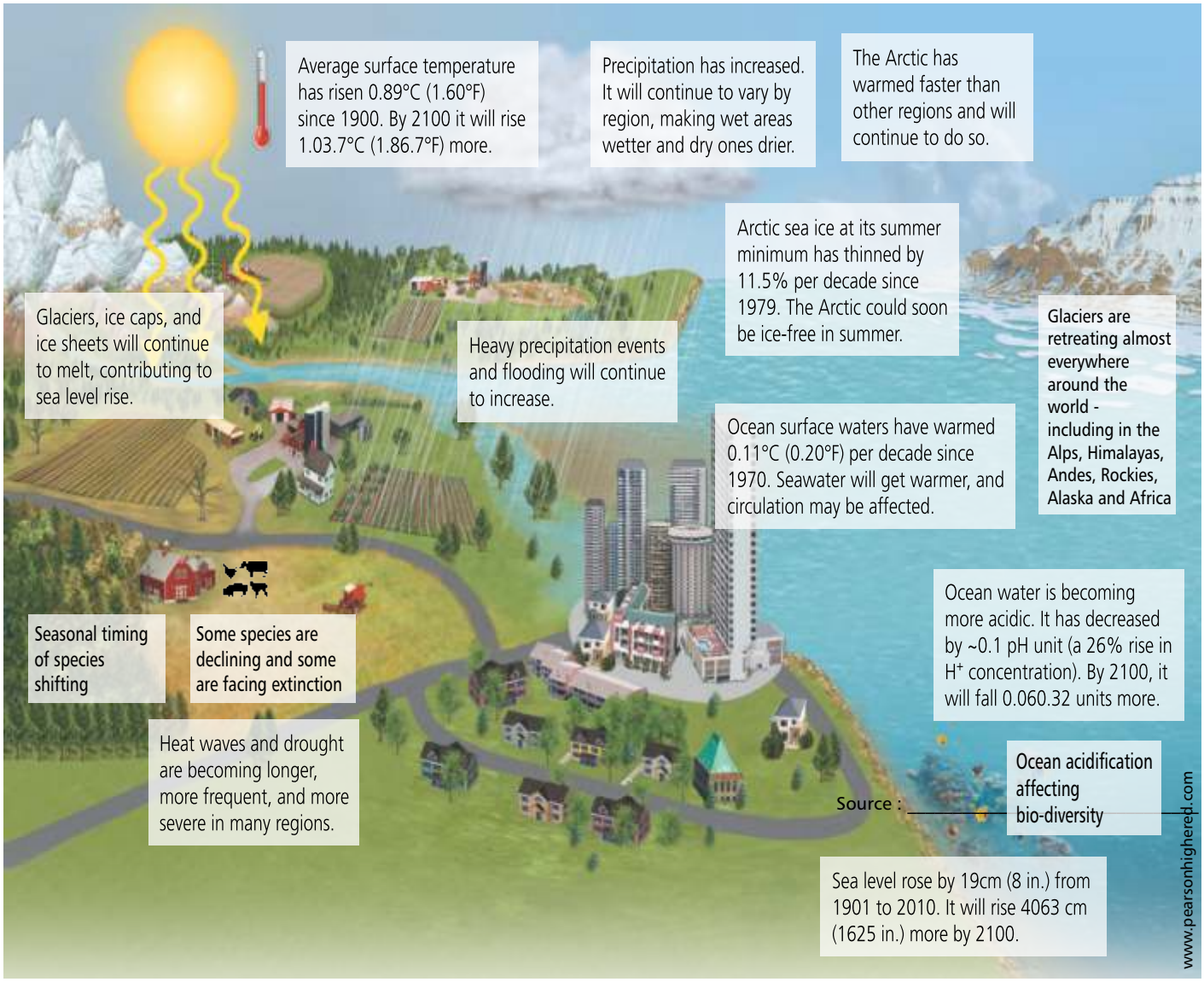
- Physical systems: includes glaciers, snow, ice and/or permafrost; rivers, lakes, floods and/or drought & coastal erosion and/or sea level effects
- Biological systems: includes terrestrial ecosystems, wildfire and marine ecosystems
- Human and managed systems: includes food production and livelihoods, health and/or economics.

The various global impacts of climate change are shown in Fig. 5 & 6.



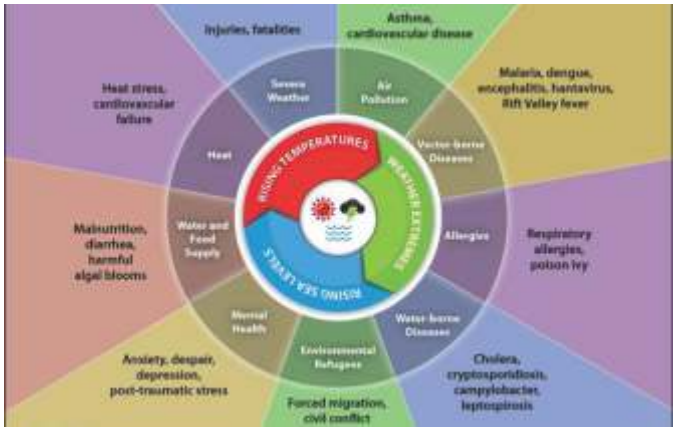
Source : IPCC

Fig. 5. Global Impacts of Climate Change



Source : Adapted from Global Climate Change, Govt. of Maldives

Fig. 6. Impact of Climate Change on Human Health



Source: www.cdc.gov

Future Projections of Climate Change

Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy. However, the magnitude and rate of future Climate Change will primarily depend on the following factors:

- The rate at which levels of greenhouse gas concentrations in our atmosphere continue to increase
- How strongly features of the climate (e.g., temperature, precipitation, and sea level) respond to the expected increase in greenhouse gas concentrations
- Natural influences on climate (e.g., from volcanic activity and changes in the sun's intensity) and natural processes within the climate system (e.g., changes in ocean circulation patterns).

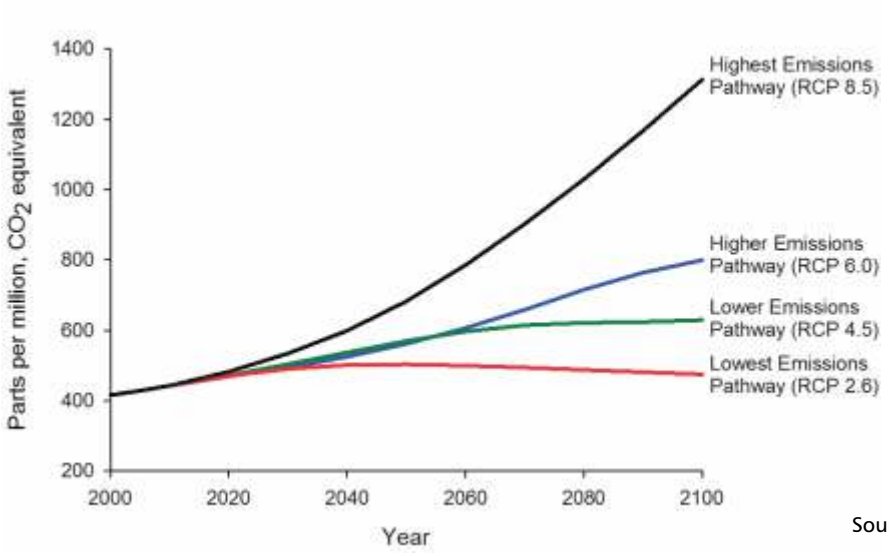
Many greenhouse gases stay in the atmosphere for long periods of time. As a result, even if emissions stopped increasing, atmospheric greenhouse gas concentrations would continue to increase and remain elevated for hundreds of years. Moreover, if we stabilized concentrations and the composition of today's atmosphere remained steady (which would require a dramatic reduction in current greenhouse gas emissions), surface air temperatures would continue to warm. This is because the oceans, which store heat, take many decades to fully respond to higher greenhouse gas concentrations. The ocean's response to higher greenhouse gas concentrations and higher temperatures will continue to impact climate over the next several decades to hundreds of years (https://www3.epa.gov).

To better understand these issues and project future Climate Change, scientists use computer models of the climate system s because it is difficult to project far-off future emissions and other human factors that influence climate, scientists use a range of scenarios using various assumptions about future economic, social, technological, and environmental conditions. The fig 7 shows projected greenhouse gas concentrations for four different emissions pathways. The top pathway assumes that greenhouse gas emissions will continue to rise throughout the current century. The bottom pathway assumes that emissions reach a peak between 2010 and 2020, declining thereafter. The graph has been created from data in the Representative Concentration Pathways Database (RCP) - Version 2.0.5. They describe four possible climate futures (RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m^2, respectively). The RCPs are consistent with a wide range of possible changes in future anthropogenic (i.e., human) greenhouse gas (GHG) emissions. RCP 2.6 assumes that global annual GHG emissions (measured in CO_2-equivalents) peak between 2010-2020, with emissions declining substantially thereafter. Emissions in RCP 4.5 peak around 2040, then decline. In RCP 6, emissions peak around 2080, then decline. In RCP 8.5, emissions continue to rise throughout the 21st century. The four RCPs are consistent with certain socio-economic assumptions but are to be substituted with the Shared Socio-economic Pathways which are anticipated to provide flexible descriptions of possible futures within each RCP.

The figure (Fig 7) shows projected greenhouse gas concentrations for four different emissions pathways from the year 2000 - 2100, spanning a range from low to high emission (intensive mitigation to limited mitigation) (taken from Van Vuuren et al., 2011 used as input to global climate models).

- The first shows rapidly increasing concentrations to ~ 950 ppm by 2100.
- The middle two show a stabilizing CO_2 concentration.
- The final shows a peak in CO_2 concentrations around 2050, followed by a modest decline to around 400 ppm CO_2, by the end of the century.

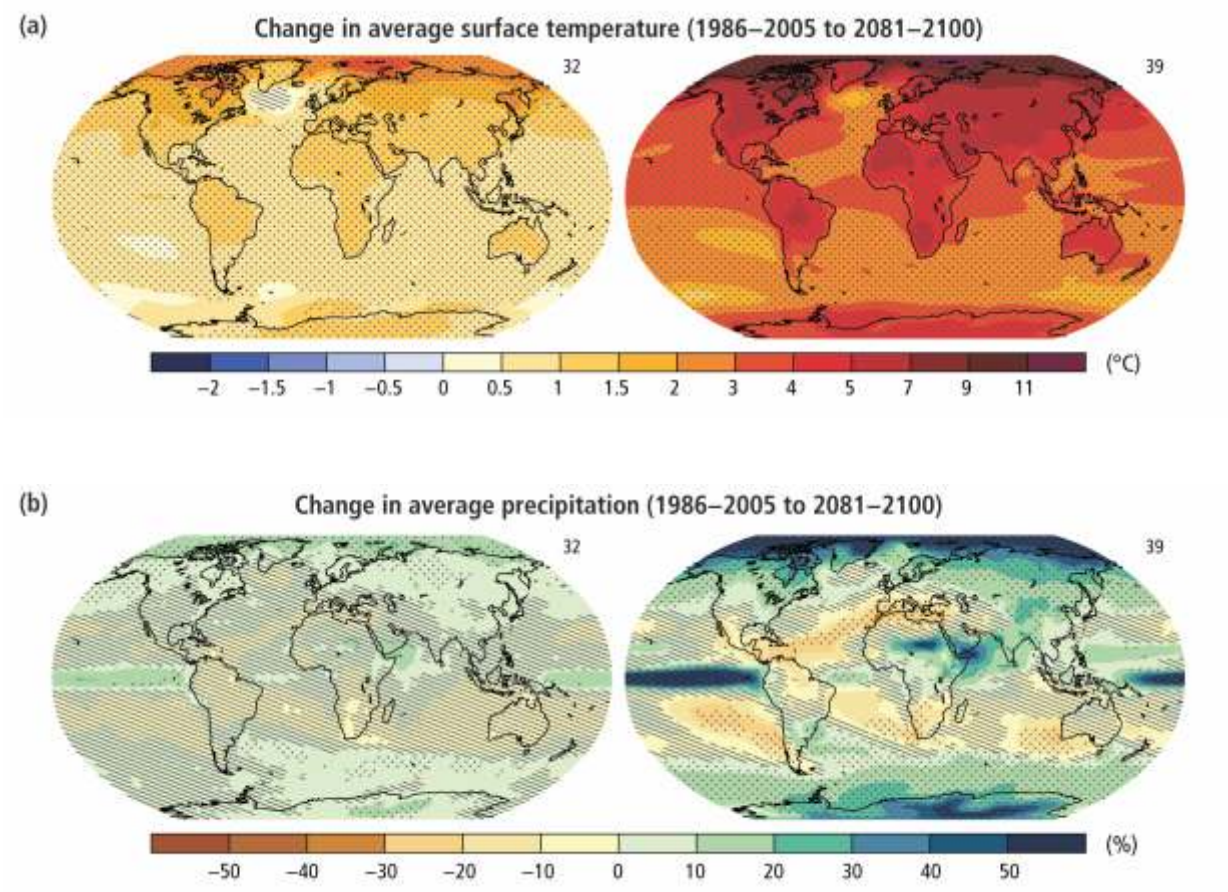
Fig. 7. Projected Atmospheric Greenhouse Gas Concentrations



RCPs are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014.

Source: https://www3.epa.gov

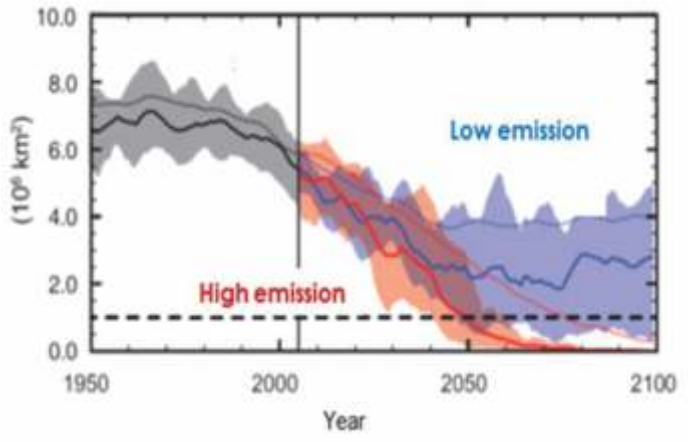
Fig. 8 (a & b). Projections about Surface Temperature and Precipitation (Average)



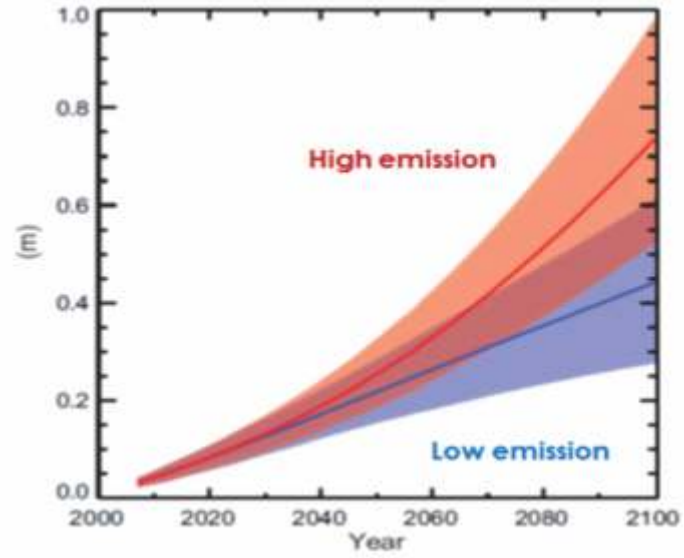
Source: IPCC AR5, WGI

Fig. 9 & 10. Other indicators projected to change

Arctic Sea Ice Extent



Global Mean Sea Level Rise



Source: IPCC

The magnitude of future Climate Change depends directly on future emissions as shown in graphs in Fig 8 with following details:

a) annual mean surface temperature change in 2081-2100) relative to 1986-2005

b) average percent change in annual mean precipitation in 2081-2100) relative to 1986-2005

The figures on the left hand side represent low emissions and high mitigation while the figures on the right hand side represent high emissions and limited mitigation. Changes in average surface temperature and average precipitation are higher in the figures showing high emissions and limited mitigation.

The graphs at Fig 9 & 10 are from the IPCC's AR5 on other indicators that are projected to change. The graph at Fig 9 shows Northern Hemisphere September sea ice extent (measured in millions of km2) between 1950 and 2100 under low and high emission scenarios. With low emissions, sea ice extent is projected at around 3 million km2 by 2100, whereas it hits the zero mark around 2080 with high emissions. The graph at Fig 10 shows global mean sea level rise (measured in meters) between 2000 and 2100 under low and high emission scenarios. With low emissions, global mean sea level rise is projected around 0.45m by 2100, whereas it is close to 0.75m with high emissions.

International Collaborations, Partnerships & Initiatives on Climate Change

Since, most environmental problems have a trans-boundary nature and often a global scope and they can only be addressed effectively through international co-operation. Several disasters in the 1960s and 70s created a fundamental need for more climate science to better understand these systems. The awareness increased on food, drought, and other climate related systems and people dependence on the Earth's climate systems. A series of UN convened conferences were held during 1970's namely United Nations Conference on Environment, Stockholm (1972), UN World Food Conference, Rome (1974) which recognized the central role of climate in world food production and UN World Water Conference in Mar Del Plata, Argentina (1976). People became more sensitive to climatic and environmental fluctuations and recorded the same. In response to these events various initiatives were taken by WMO, UNEP, FAO, UNESCO & WHO to increase awareness about food, drought, and other climate related systems which were much more sensitive to fluctuations. It was showcased increased scientific knowledge that GHGs caused warming, and that governments around the world needed to take some sort of pre-emptive action before system collapse and which gave a way to organization of World Climate Conferences as under:

1) First World Climate Conference (FWCC or WCC-1)

Held on :	12-23 February 1979
Place & organized by:	Organized in Geneva, Switzerland by WMO, UNEP, FAO, UNESCO and WHO

Major Features :

- first major international meeting on Climate Change.
- assessed the state of knowledge of climate
- considered the effects of climate variability and change on human society.
- explored the affect of Climate Change on human activities.
- issued a declaration calling on the world's governments "to foresee and prevent potential man-made changes in climate that might be adverse to the well-being of humanity".

Source: https://www.wmo.int/pages/themes/climate/international_wcc.php

Outcomes (led to) :

- Creation of Intergovernmental Panel on Climate Change (IPCC) by WMO and UNEP in 1988.
- UN Conference on Desertification (1998)
- UN Economic and Social Council (ECOSOC) Resolution endorsing the WMO initiation of a World Climate Programme that drew attention to the global condition.

The opening of the World Climate Conference in February 1979.

Box 5. Intergovernmental Panel on Climate Change (IPCC)

First World Conference on Climate Change led to the creation of the IPCC (Intergovernmental Panel on Climate Change). IPCC is the leading international body for the assessment of climate change established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988. IPCC was established with the following goals:

1. Assess available scientific information on Climate Change
2. Assess the environmental and socio-economic impacts of Climate Change
3. Formulate response strategies

As an intergovernmental body, membership of the IPCC is open to all member countries of the United Nations (UN) and WMO. Currently 195 countries are Members of the IPCC. Governments participate in the review process and the plenary sessions, where main decisions about the IPCC work programme are taken and reports are accepted, adopted and approved.

The IPCC is currently organized into following three Working Groups and a Task Force on National Greenhouse Gas Inventories.

- Working Group I deals with "The Physical Science Basis of Climate Change",
- Working Group II with "Climate Change Impacts, Adaptation and Vulnerability"
- Working Group III with "Mitigation of Climate Change".

It publishes major climate reports every five years. These reports are the primary source for many policy maker's (and media's) climate science and knowledge. The IPCC published first Assessment Report was completed in 1990 and the Fifth Assessment Report in 2014.

Source: http://www.ipcc.ch

- Establishment of the World Climate Programme (WCP) and the World Climate Research Programme (WCRP) under the joint responsibility of the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU).

2) The Second World Climate Conference (SWCC)

Held on :	29 October to 7 November 1990
Place & organized by:	Organized in Geneva, Switzerland by WMO, UNEP, UNESCO, the UNESCO Intergovernmental Oceanographic Commission (IOC), FAO and the International Council for Science (ICSU).

Major Features:

- an important step towards a global climate treaty & somewhat more political than the first conference.
- reviewed the WCP set up by the first conference.
- IPCC got completed for this conference.
- scientists & technology experts at the conference issued a strong statement highlighting the risk of Climate Change.
- issued a Ministerial Declaration only after hard bargaining over a number of difficult issues, though the declaration disappointed many of the participating scientists as well as some observers because it did not offer a high level of commitment.

Outcomes (led to) :

- Establishment of the United Nations Framework Convention on Climate Change (UNFCC), of which the Kyoto Protocol is a part.
- Development of an International Geosphere-Biosphere Programme (IGBP).
- Establishment of the Global Climate Observing System (GCOS)
- The Conference Statement of SWCC endorsed four streams of international activities:
  - The future structure of the World Climate Programme (WCP)
  - Special needs of the Developing Countries to build up their capabilities

The Secretary-General of WMO, G.O.P. Obasi, addressing the opening Ministerial Sessions of SWCC, Geneva, 6th November 1990.

Box 6. United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is a first international environmental treaty (also known as a Multilateral Environmental Agreement) to prevent dangerous anthropogenic interference with the climate system, at the Earth Summit in Rio de Janeiro from 3 to 14 June, 1992, then entered into force on 21 March, 1994. The UNFCCC is also the name of the United Nations Secretariat charged with supporting the operation of the Convention, with offices in Haus Carstanjen, and UN Campus [known as: Langer Eugen] Bonn, Germany.

The framework set no binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. Instead, the framework outlines how specific international treaties (called "protocols" or "Agreements") may be negotiated to set binding limits on greenhouse gases. It recognises three principles:

- Precautionary principle: scientific uncertainty about the impacts of Climate Change does not justify postponing measures
- Principle of common but differentiated responsibility: all emissions have an impact on Climate Change, but the more developed countries have a greater responsibility for the current concentration of GHGs
- Principle of the right to economic development: measures taken to combat Climate Change should not negatively affect the priorities of developing countries, which are, inter alia, sustainable economic development and poverty eradication.

Countries that are party to the UNFCCC meet at the end of each year for the "Conference of the Parties" (COP). It is during these conferences that the major UNFCCC decisions are made. The 21st COP will be held in Paris (France) at the Le Bourget site from climate system

194 countries signed the UNFCCC showing near universal agreement that there is a problem and that action is required against Climate Change. Further, to provide UNFCCC's Conference of the Parties with advice, the Subsidiary Body for Scientific and Technological Advice (SBSTA) and Subsidiary Body for Implementation (SBI) were also created.

- Cooperation in international research through the WCRP, IGBP and other related international programmes
- Coordinated international activities and policy development through global measurement and research efforts, assessment functions of IPCC.

3) The World Climate Conference - 3

Year : 31 August to 4 September , 2009

Place & organized by: Geneva, Switzerland by the WMO, in collaboration with the UNESCO, UNEP, FAO, ICSU and other intergovernmental and non-governmental partners.

Major Features:

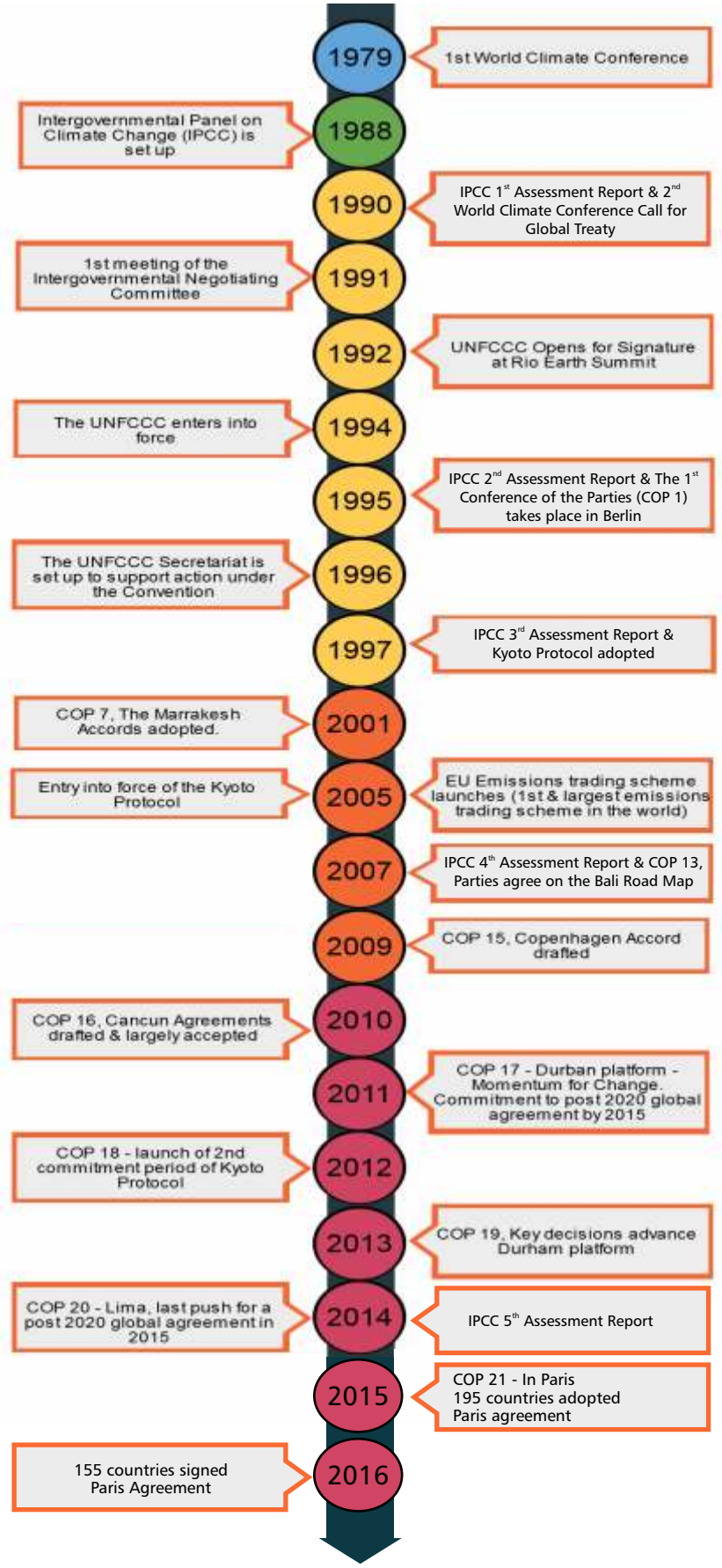
- focused was on climate predictions and information for decision-making at the seasonal to multi-decadal timescales.
- created a global framework that will link scientific advances in these climate predictions and the needs of their users for decision-making to better cope with changing conditions.
- aimed to increase commitment to and advancements in climate observations and monitoring.

Outcomes (led to) :

- Contributed to the achievement of the United Nations Millennium Development Goals (MDGs) and broader UN climate goals, including the Hyogo Framework for Action on Disaster Risk Reduction.
- Complemented global work under way to help societies adapt to Climate Change in line with Bali Action Plan, especially the Nairobi Work Programme.
- Inputs to UNFCC COP-15 in December 2009 meeting for climate mitigation in Copenhagen.

Swiss President and Finance Minister Hans-Rudolf Merz addressing the delegates during the opening of the WCC-3, Geneva August 31, 2009.

Major Milestones related to Climate Change



Glossary

COP	:	Conference of the Parties to the UNFCCC
UNFCCC	:	United Nations Framework on Climate Change
IPCC	:	Intergovernmental Panel on Climate Change
UNEP	:	United Nations Environment Programme
WMO	:	World Meterological Organisation

COP 21: Paris Agreement on Climate Change

At Paris Climate Conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal to combat Climate Change and unleash actions & investment towards a low - carbon, resilient and sustainable future. The agreement is due to enter into force in 2020. The Paris agreement sets out a global action plan to put the world on track to avoid dangerous Climate Change by limiting global warming to well below 2°C and to drive efforts to limit the temperature increase even further to 1.5° Celsius above the pre-industrial days levels.

The major outcomes of the Agreement are :

Mitigation: reducing emissions

Governments agreed

- a long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels;
- to aim to limit the increase to 1.5°C, since this would significantly reduce risks and the impacts of Climate Change;
- on the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries;
- to undertake rapid reductions thereafter in accordance with the best available science.

Before and during the Paris conference, countries submitted comprehensive national climate action plans (INDCs). These are not yet enough to keep global warming below 2°C, but the agreement traces the way to achieving this target.

Transparency and global stocktake

Governments agreed to

- come together every 5 years to set more ambitious targets as required by science;
- report to each other and the public on how well they are doing to implement their targets;
- track progress towards the long-term goal through a robust transparency and accountability system.

Adaptation

Governments agreed to

- strengthen societies' ability to deal with the impacts of Climate Change;
- provide continued and enhanced international support for adaptation to developing countries.

Loss and damage

The agreement also

- recognises the importance of averting, minimising and addressing loss and damage associated with the adverse effects of Climate Change;
- acknowledges the need to cooperate and enhance the understanding, action and support in different areas such as early warning systems, emergency preparedness and risk insurance.

Support

- The EU and other developed countries will continue to support climate action to reduce emissions and build resilience to Climate Change impacts in developing countries.
- Other countries are encouraged to provide or continue to provide such support voluntarily.
- Developed countries intend to continue their existing collective goal to mobilise USD 100 billion per year by 2020 and extend this until 2025. A new and higher goal will be set for after this period.

India's Initiatives towards Climate Change

India is already a major greenhouse gas emitter and key player in the global climate issue. The country is highly vulnerable to the impacts of Climate Change, Like other countries with emerging economies, India faces the dual challenge of reconciling its rapid economic growth with a pressing need to address Climate Change. In response, it has enhanced its international and domestic efforts to reduce its greenhouse gas emissions while addressing critical issues such as poverty, food security and access to healthcare and education (Source: http://www.wri.org/). The key attributes of India towards Climate Change are given below and major actions/initiatives towards Climate Change are shown in Timeline.

1. There is no legal binding commitment for India under UNFCCC till date.
2. MoEFCC is the nodal agency for Climate Change issues in India. It has constituted Working Groupson the UNFCCC and Kyoto Protocol.
3. Till date 30 Indian states and Union territories including Punjab have prepared their State Action Plan on Climate Change (SAPCC) based broadly on a framework similar to National Action Plan on Climate Change (NAPCC) (having 8 missions) primarily focusing on adaptation.
4. Prior to the 15th session of the Conference of the Parties (COP) in Copenhagen in December 2009,India declared a voluntary goal of reducing the emissions intensity of its GDP by 20-25%, over 2005 levels by 2020, despite having no binding mitigation obligations as per the Convention. United Nations Environment Programme (UNEP) in its Emission Gap Report 2014 has recognized India as one of the countries on course to achieving its voluntary goal.
5. India for reduction in Green House Gas emissions (Under UNFCCC), in its Intended Nationally Determined Contributions (INDC) outlines to undertake post-2020 climate actions as illustrated in Box 7.

Photo credit : Gururaj Vaidya

Box 7. India's Intended Nationally Determined Contribution (INDC)

Under UNFCCC, India for reduction in Green House Gas emissions, in its Intended Nationally Determined Contributions (INDC) outlines to undertake following post-2020 climate actions :

- to reduce the Emissions Intensity of its GDP by 33 to 35 % by 2030 from 2005 Level
- to achieve 40% commutative electricity installed capacity from non-fossil fuel based energy sources by 2030
- to create additional Carbon Sink of 2.5 to 3 Billion tonnes of CO_2 Equivalent through additional forest and tree cover by 2030
- better adaptation with climate resilient agriculture and water conservation
- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
- To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
- To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Source: Intended Nationally Determined Contribution on submitted by Government of India, MoEF & CC, GoI

Timeline of India's major actions towards Climate Change

1992	India being concerned about the impacts of Climate Change signed the UNFCCC and ratified it in November 1993
2001	Energy Conservation Act enacted to encourage efficient use of energy and its conservation
2002	India acceded to Kyoto Protocol
2004	1st National communication to UNFCCC secretariat by MoEF, GoI(the nodal agency for Climate Change issues in India)
2005	• IInd National communication to UNFCCC secretariat by MoEF, GoI (the nodal agency for Climate Change issues in India) • National Electricity Policy (NEP) underscores the focus on universalizing access to electricity and promoting renewable sources of energy
2007	• Prime Minister's Council on Climate Change (PMCCC) was constituted. A high level advisory group formed with the mandate of coordinating the national action plans for assessment, adaptation and mitigation of Climate Change and consisted of representatives from the government, industry and civil society. • National Policy for Farmers focusing on sustainable development of agriculture
2008	National Action Plan on Climate Change (NAPCC) was launched, outlining measures to promote sustainable development, while also yielding co-benefits to address Climate Change through eight national missions (solar energy, enhanced energy efficiency, sustainable habitat, water, sustaining Himalayan eco-system, green India, sustainable agriculture and strategic knowledge for Climate Change)
2009	• Integrated Energy Policy (IEP) received cabinet approval and it sets out the roadmap for the country plans to achieve the balance among development, environmental protection, citizens' rights, energy security and a host of other priorities and concerns • Indian Network for Climate Change Assessment (INCCA) was launched under the Climate Change Action Programme (CCAP) of the MoEFCCo enhance knowledge about the impacts of Climate Change at the national and sub national level..
2010	• National Clean Energy Fund (NCEF) was created using the carbon tax - clean energy cess(or Coal cess) for funding research and innovative projects in clean energy technologies of public sector or private sector entities, upto the extent of 40% of the total project cost • Expert Group on Low-Carbon Strategies for Inclusive Growth was set up by the Planning Commission, Government of India, to suggest low carbon pathways consistent with inclusive growth in country and to provide sector specific recommendations to support the formulation of the country's 12th Five Year Plan (2012-17). The high level Expert Group was composed of representatives from relevant government ministries, industry, think tanks and research institutions • Removal of subsidy on petroleum products
2011	• Renewable energy certificates trading commenced • India's National Bank for Agriculture and Rural Development (NABARD) has been accredited as a National Implementing Entity (NIE) for India for the Adaptation Fund created under UNFCCC.
2012	• Rules were notified for Perform Achieve and Trade (PAT) scheme to promote/incentivize energy efficiency in industries by the Ministry of Power (MoP), in consultation with the Bureau of Energy Efficiency for a domestic market-based mechanism • Expert Committee for drafting the Auto Fuel Vision and Policyfor the country to recommend a roadmap for improving auto fuel quality in India till 2025, as well provide recommendations on other issues, including suitable mix of auto fuels, vehicular emission norms for various categories of vehicles, use of alternate fuels and fiscal measures for funding requisite technology upgrades.
2013	National Electric Mobility Mission Plan (NEMMP 2020) fuel consumption standards were notified. to promote adoption of hybrid & electric vehicles in the country.
2014	• PMCCC was reconstituted • National Adaptation Fund instituted by Government of India and 100 Smart Cities Programme announced • Removal of subsidy on diesel &also limits placed on the amount of subsidized LPG
2015	• The National Institution for Transforming India (NITI) Aayog, a new institution that replaced the Planning Commission, released a roadmap for accelerated renewable energy deployment as its first initiative. • Government of India substantially enhanced Renewable energy target to 175 GW (comprising of 100 GW of solar power, 60 GW of wind energy, 10 GW of small hydro power & 5 GW of biomass-based power) by 2022. The 175 GW target by 2022 will result in abatement of 326 million tons of CO2 equivalent/year. The enhanced solar target by itself is anticipated to save about 165 million tonnes of CO2 emissions/ year • Submission of INDC

Eight National Missions to Address Climate Change

Source : SAPCC, 2014

State Perspective on Climate Change

With increasing impacts of Climate Change at local levels, the state is concerned about Climate Change, due to its large share of population being engaged in climate sensitive sector of Agriculture. In addition, Punjab being traditionally the granary of India, the sustenance of this sector vis a vis Climate Change is a key to the food security of the Nation. Further, as Punjab is thrusting ahead in investing in infrastructure (especially up scaling rural habitats), industries and new technologies, Climate Change concerns need to be kept in view while ensuring the sustainability of these systems (SAPCC, 2014).

Observed and Projected Climate of Punjab

The five climatic regions of Punjab are shown in Map 3 and the pattern of annual average rainfall in the state during 1970-2010 is depicted in graph at Fig. 11. In 2010, the maximum and minimum temperatures in the Punjab region have increased by 0.5-1.0°C with respect to the base line 1971-2000 as shown in Map 3 & Fig. 11. Analysis of inter-annual variability of area weighted seasonal monsoon rainfall expressed as the percentage departures from Long Period Average (LPA) for the period 1901-2011 for Punjab indicates that during the period 1901 -2011, the lowest and second lowest seasonal rainfall in Punjab have occurred in 1911 (-51.0%) and in 1987 (-67.6%) respectively. Highest and second highest seasonal rainfall in Punjab have occurred in year 1950 (91.2%) and in 1988 (119.1%) as shown in Fig 12.

Map 3 . Climate of Punjab

Source : Department of Soil & Water Conservation, Punjab as cited in SAPCC, 2014

An Overview of Punjab

- Occupy 1.57% geographical area of India
- 5 Agro-climatic zones
- 27.7 million People (more than 2% of total population of India)
- Falls in Indus Basin & Major 3 Rivers: Ravi, Beas & Satluj (perennial) along with Ghaggar (seasonal)
- Contributes 13-14 % of Total food grain production of the country
- 84% area under agriculture
- 28 % share of Industry Sector in GSDP
- 37% Urbanization

Major Challenges

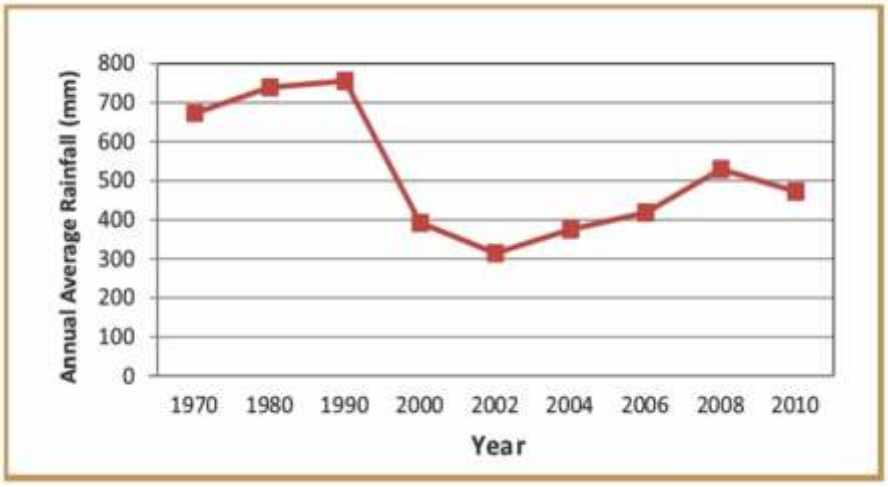
- Growing Energy Demand
- Groundwater depletion
- Stress on Natural Resources
- Climate Variability & Increasing Vulnerability to Climate Change.

Sectoral Challenges

- Electricity consumed : 34% in Industrial sector, 31 % in Agriculture sector & 32% in residential & commercial sector
- 80% blocks w.r.t. goundwater over exploited
- 27 % sewage treated in Class-I cities
- 20% increase in vehicles in last three decades
- 32% Electricity consumed in residential & commercial sector
- 95% share of MSMEs in Industrial units
- PM10 above prescribed standard
- 17 million Tonnes Paddy Straw produced

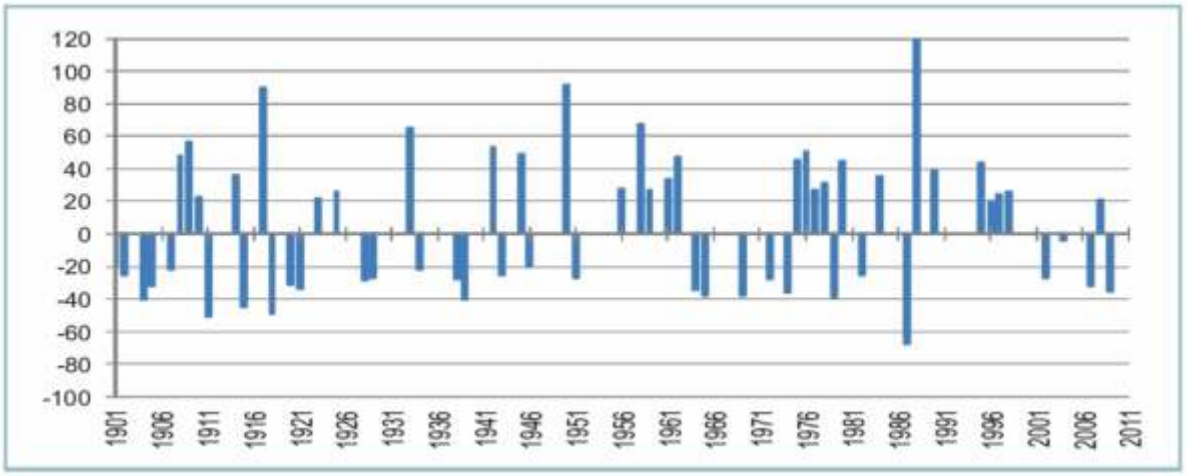
Source: CRGGS,2015

Fig. 11. Annual Average Rainfall in Punjab (mm), 1970-2010



Source : Environment Statistics of Punjab, 2011 as cited in SAPCC, 2014

Fig. 12. Percentage departure of rainfall in mm between 1901 and 2011 in Punjab with respect to the corresponding Long Period Average (LPA)

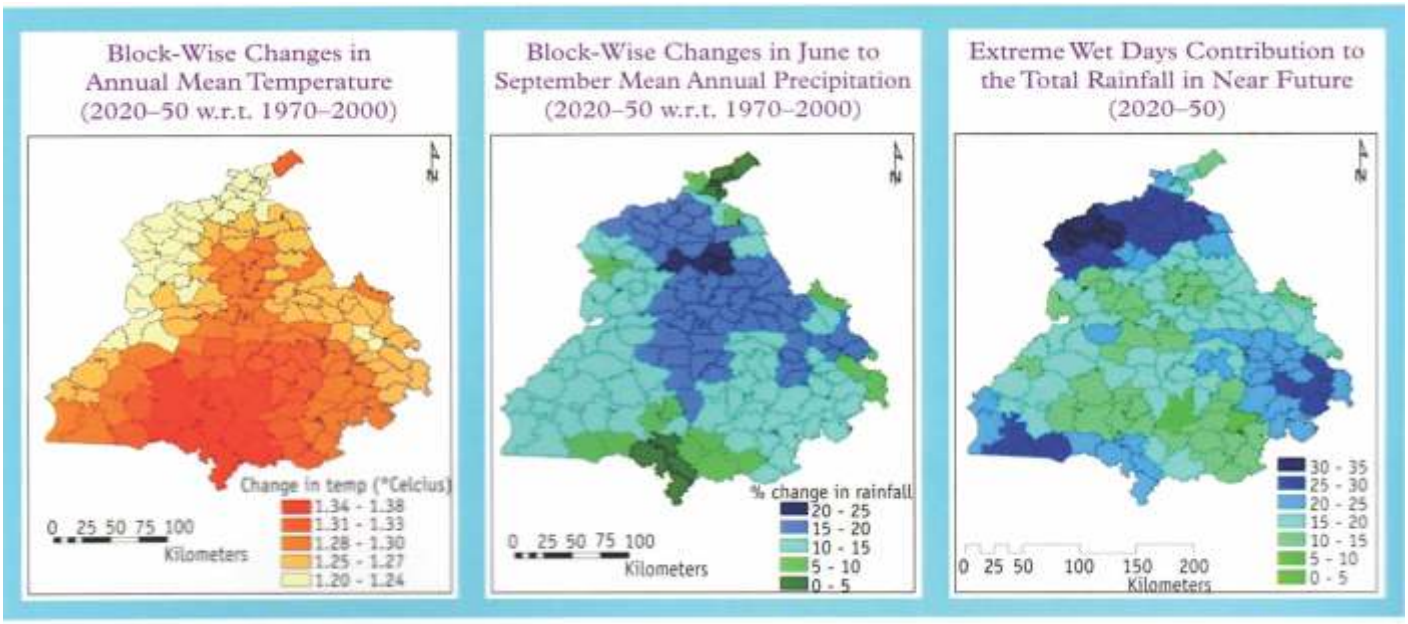


Source: SAPCC,2014

Projections about Climate Change in Punjab

- The climate model used in the study done by Energy and Resources Institute (TERI) in collaboration with Global Green Growth Institute and Department of Science & Technology projects the following major concerns after climate modelling for the state:
- The overall warming with annual mean temperature projected to increase by 1.2°C - 1.4°C for 2021-50 period relative to 1971-2000.
- The mean annual minimum temperature (Tmin) also is projected to increase over the study domain area in the range1.2°C - 1.4°C. Mean annual maximum temperature (Tmax) over the State is projected to increase by 0.5°C - 1.25°C. Relatively larger changes projected for minimum temperatures for the future. This corroborates with the historical trends over India.
- Increase in minimum temperature has many impacts not only on plants and crops but also on human comfort as well. This also indicates that night time temperatures also will increase in the near future relative to the baseline period.
- The analyses of baseline (1970-2000) and near future (2021-50) climate simulations over the study area revealed an increase in future summer monsoon (June-September) precipitation in the

Fig. 13. Projected Changes in Climate Parameters in Punjab



Source: CRGGS,2015

near future relative to the baseline period. The increase in mean annual summer monsoon rainfall is in the range of 0-20 per cent of the baseline rainfall.

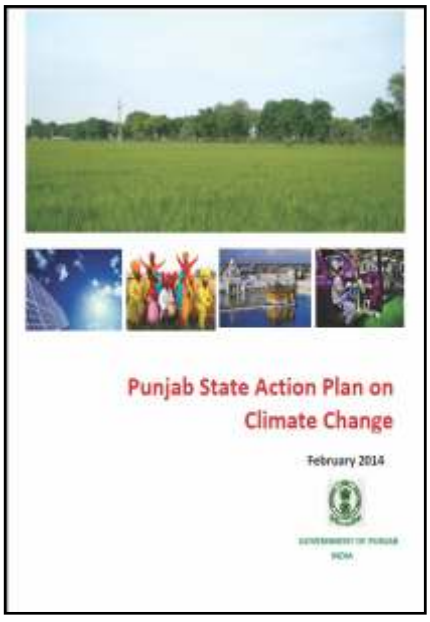
- The analysis indicates that towards late 2030s and early 2040s, the State will experience higher number of extreme wet days. This implies that in the summer-monsoon season in the near future, there will be more break periods in terms of precipitation.
- A higher level of relative humidity is also expected in the near future.

Further, the analysis in Fig 13 also predict the affects on state's soil and water parameters. Thus, taking the cognizance of the potential impact of Climate Change the Punjab State has also taken following initiatives stated as under:

I. Preparation of State Action Plan on Climate Change: The Punjab SAPCC has been prepared by the Punjab State Council for Science and Technology (PSCST) under the aegis of Department of Science, Technology & Environment, Government of Punjab (which is the focal point for Climate Change matters in the Punjab government) with the technical support of GIZ and financial support of Ministry of Environment & Forests, Government of India

The Punjab SAPCC provides a platform to integrate Climate Change into the policies and programmes of the state to ensure the ultimate objective of sustainable development with inclusive growth. The strategies have been drafted keeping in view the existing concerns, on-going developmental programmes in different sectors, the institutions that are managing these programmes, and the assessed vulnerabilities of the various sectors to Climate Change.

The strategies in SAPCC document are in line with the eight missions of the National Action Plan on Climate Change as depicted in Box 8. The SAPCC assigns state specific targets for each strategy and the actions are geared towards achievement of these targets. The targets as well as the strategies and actions have been developed in consultation with the stakeholders concerned from government departments, universities, industry association and other experts. The actions in the strategies



Box 8. Punjab State objectives & targets vis-a-vis the 8 National Missions

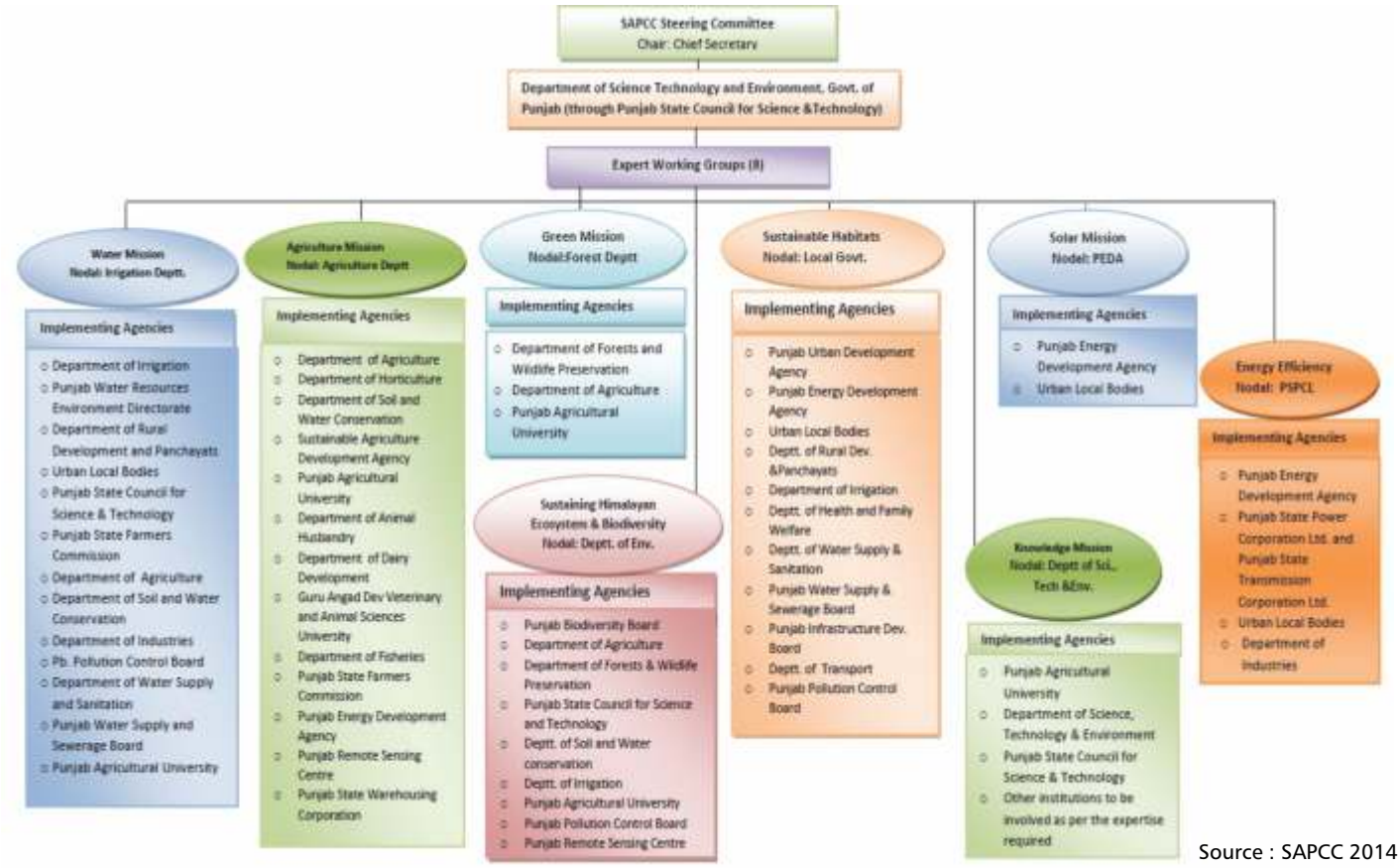
Source : SAPCC, 2014

have been budgeted for the 12th and the 13th plan. Implementation of SAPCC is shown in Figure 14.

II. **State Steering Committee on Climate Change**: The State Steering Committee will provide the overall guidance, supervision and coordination to the whole Process of preparation of State level Climate Change Strategy and Action Plan (SCCSAP) through participatory on planning process involving all major stakeholders.

III. **Establishment of Climate Change Knowledge Centre:** Punjab State Council for Science & Technology has established the Punjab State Climate Change Knowledge Centre (PSCCKC) in the state under National Mission on Strategic Knowledge for Climate Change (NMSKCC) with support from the Department of Science & Technology, Government of India (DST, GOI). DST, GOI has provided financial assistance for this Centre to take up activities as identified under State Action Plan on Climate Change in coordination with various line departments. Major objectives of the PSCCKC are to address challenges and implications of Climate Change with focus on climate sensitive and

Fig. 14. Implementation of State Action Plan on Climate Change in Punjab



Source : SAPCC 2014

vulnerable sectors in short and long term scenarios and to take state specific adaptation and mitigation initiatives including vulnerability and risk assessment. The PSCCKC shall articulate and act as a functional knowledge centre, catering to the information and knowledge needs of policy makers, scientific community and general public on Climate Change issues through tailor made outreach programs. The major objectives of PSCCKC are given in Box 7.

IV. Ongoing Major Current Projects related to Climate Change in Punjab : The major ongoing current projects related to Climate Change in Punjab are as follows:

1. Towards Climate Resilient Livestock Production System in Punjab: The MoEF&CC, GoI has approved a Project titled "Towards Climate Resilient Livestock Production System in Punjab" prepared by PSCST with technical support of GIZ for funding under National Adaptation Fund on Climate Change (NAFCC). The project is for 5 years duration and is proposed to be implemented in three districts of Punjab i.e. Ludhiana, Bhatinda and Tarn Taran. The objectives of the project are:

- Ensure sustainable levels of livestock production in small and marginal farmer households (HHs) in heat stress conditions through activities like artificial insemination, estrus synchronisation, heat resistant sheds, fodder availability and disease forecasting system.
- Climate Proofing of registered Gaushalas/ construction of climate smart model cattle pounds (Cattle shed) housing 2000 stray cattle having provisions of rainwater harvesting, solar energy, biogas plants and energy efficient lighting like CFLs etc.
- Develop weather indexed insurance to compensate loss in income of small and marginalised farmers due to decrease in milk yield of buffalo/cattle based on the correlation of THI.
- Capacity building and dissemination of knowledge products.

Box 9. Major Objectives of Punjab State Climate Change Knowledge Cell

- Building on the existing knowledge to further develop deeper understanding about the key Climate Change issues, processes and the anthropogenic drivers.
- Creating Climate Change Information Bank and Strengthening Knowledge Network.
- Documentation and dissemination of strategic Climate Change knowledge.
- Undertaking/promoting Research and Development of new and innovative Climate friendly technologies in collaboration with research institutes and universities.
- Technology identification and pilot scale demonstration & extension.
- Capacity building of various stakeholders and institutions.
- Development of target specific resource material including educational multi-media CDs and video films.
- Managing and interpreting data and information and to address Intellectual Property Rights Issues.
- Undertake Climate Change related vulnerability and risk assessment.
- Developing knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science and facilitate data sharing and exchange.
- Complementing the efforts under other national missions, strengthen indigenous capacity for the development of appropriate technologies for responding to Climate Change through adaptation and mitigation and promote their utilization by the Government and societies for sustainable growth of economies.

The Project will be implemented through a multi-departmental coordination where Guru Angad Dev Veterinary and Animal Sciences University, Punjab Agricultural University, Deptt. of Animal Husbandry, Dairy Development Board, Punjab Energy Development Agency and PSCST are involved.

2. **Capacity Building on Climate Change:** PSCST being the nodal agency for Climate Change is taking up capacity building activities for adaptation and mitigation of Climate Change with support from MoEF& CC, GoI. PSCCKC has also been set up by PSCST with the support of Dept. of Science & Technology, Government of India under National Mission on Strategic Knowledge for Climate Change (NMSKCC). Regular workshops and training programmes with the concerned departments/institutes are being organized for capacity building of the stakeholders for effective implementation of SAPCC and formulation of projects for accessing various Climate funds.

3. **Technological Adaptation for Gainful Utilization of Paddy Straw:** A project on utilization of paddy straw for briquette making and its utilization in brick kilns has been approved by MoEF&CC, GoI under Climate Change Action Plan (CCAP). The specific objectives of the project are:

    - Adapting & demonstrating existing technology to promote gainful utilization of paddy straw as a fuel in various sectors.
    - Establish Cost effective technology for chopping and briquetting of paddy straw.

Capacity building programmes organized by PSCST

- Encourage entrepreneurs/ brick kiln owners for adaptation of paddy straw briquette manufacturing technology in other parts of the State as well as adjoining States.

The Project will be implemented by PSCST in collaboration with industries and brick kiln operators which will help in utilizing this biomass/agro waste at local level and will reduce industry's dependency on fossil fuel. The activities mentioned under project would also provide employment for collection of paddy straw & in paddy straw briquette manufacturing and also helps in various preventing various environmental issues like reducing GHG emissions and suspended air borne particulate matter, etc.

4. **Science Express-Climate Action Special:** Science Express - Climate Action Special (SECAS) was designed by Ministry of Environment, Forest & Climate Change (MoEF&CC) and Ministry of Railways, Government of India to create awareness among various sections of society about basic concepts of Climate Change, its impacts and related mitigation and adaptation strategies. The train included 16 coaches out of which 8 coaches have exhibitions highlighting information, case studies and material related to various aspect of Climate Change. SECAS will travel across the country for about 7 months, halting at 64 locations in 20 States. It halted at three stations (Patiala junction: 2nd - 4th, Nov., 2015, Hoshiarpur junction: 14th to16th Nov., 2015, Pathankot junction: 24th to 27th Nov., 2015) of Punjab also.

PSCST actively mobilized officials and masses of various districts for visiting the train at their nearest halting stations. During the halt officials from the Council organized number of activities including talks/lectures on State Action Plan on Climate Change, quiz competitions and games on environment awareness, biodiversity conservation, etc. Large number of students, teachers and experts from different schools, colleges, universities and other institutions enthusiastically visited the train. Around 391 no. of schools including about 41,007 students have visited the train at three different stations. Apart from it around 1414 teachers and number of experts from the region also attended the event.

The ENVIS Team welcomed the train at Pathankot platform and undertook the activities as illustrated below :

ENVIS Centre, PSCST motivated/ mobilized various academic institutions & schools to send their students to visit SECAS. The following activities were conducted on the platform:

- ENVIS team discussed the components of the Climate Change with students and teachers. Important tips on awareness about environmental conservation were provided to mitigate the effects of Climate Change.
- Fun activities like Snakes and ladders and quiz were organized for students and winners were provided ENVIS newsletters as prizes.
- Separate exhibition was organized on platform to create awareness about state specific environmental & Climate Change related issues. The exhibition included posters/panels. Resource material was also distributed to generate inquisitiveness amongst teachers & students.

ENVIS team creating awareness on Climate Change issue at Pathankot railway station during SECAS halt.

Dr S.S. Ladhar, Additional Director Environment, PSCST delivering lecture on 'Towards Smart Agriculture' at India Pavilion, COP21, Paris

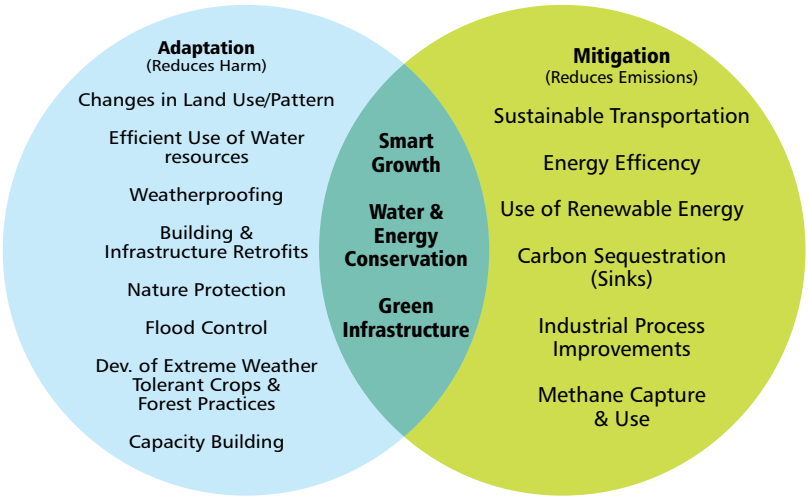
5. **Participation in India Pavilion in COP-21 in Paris:** At CoP 21, Dr Satnam Singh Ladhar, Additional Director Environment, PSCST represented Punjab and gave presentation on 'Towards Climate Smart Agriculture' during the side event titled 'Climate Change Planning and Actions at Sub-National Level' hosted by United Nations Development Programme (UNDP) held on 5th December, 2015. The presentation highlighted the Climate Change concerns of the State with regard to sustainable agriculture. Resource material addressing issues/concerns, adaptation strategies, key achievements and way forward related to different sectors including agriculture, water, managing paddy straw was also distributed.

Way Forward

Both natural and anthropogenic forces influence the Earth's climate but recently human activities have come to play a major role in deteriorating it. It is evident that the Climate Change is well underway, and further increase in greenhouse gas emissions will intensify global warming and cause severe and diverse impacts around the world. The nature of the risks of Climate Change is increasingly clear such as rise in sea level, shrinking of ice caps, retreating of glaciers, acidification of oceans and many others. As scientists and policymakers come to better understand anthropogenic Climate Change and its environmental, economic, and social consequences, more and more of them are urging immediate action. Reducing greenhouse gas emissions and taking other steps to mitigate and adapt to Climate Change represent the foremost challenges for our society in the near future.

As per IPCC report 2014, responding to Climate Change involves making choices about risks in a changing world. The report identified vulnerable people, industries, and ecosystems around the world. It reported that the risk from a changing climate comes from vulnerability (lack of preparedness) and exposure (people or assets in harm's way) overlapping with hazards (triggering climate events or trends). Each of these three components needs attention at local, national and international level to decrease risk.

In view of above, it can be visualized that there are still significant road blocks to success to address Climate Change issue. Perhaps the biggest challenge for the countries is to focus on increasing cuts in annual emissions that will collectively give a good chance of remaining below the danger limit of two degrees. Thus, one should think globally and act locally to deal with Climate Change.



References

CMS Environment, 2007. A Report on International Summit on Climate Change: We Cause Global Warming.

Consumer Education & Research Centre (CERC), 2016. Climate Change and Eco Friendly Development. Green Insights, ENVIS Newsletter on Eco-labelling and Eco-friendly Products. Vol. 10, No.4, Jan-March, 2016.

CRGGS, 2015. Climate Resilient Green Growth Strategies for Punjab for Policy Makers . Implemented by Energy Resources Institute in collaboration with The Global Green Growth Institute and Nodal Support from Department of Science, Technology & Environment and Punjab State Council for Science & Technology.

Department of Ecology, Environment & Remote Sensing, J& K, 2015. Climate Change & Concerns of J& K. ENVIS Newsletter , October – December, 2015.

Environment Statistics of Punjab, 2015. Economic and Statistical Organization of Punjab.

Intergovernmental Panel on Climate Change (IPCC), 2013. "Working Group I Contribution to the IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis Summary for Policymakers".

Intergovernmental Panel on Climate Change (IPCC), 2014. "Working Group II Contribution to the IPCC Fifth Assessment Report: Climate Change 2014: Impacts, Adaptation, and Vulnerability : Summary for Policymakers.

.Jearth N., Ladhar S.S., Kaur S. , Sharma V. , Saile P. , Tripathi P., Bhattacharaya S. and Parwana, 2014.. Punjab State Action Plan on Climate Change (SAPCC). Punjab State Council for Science & Technology(PSCST), and GIZ(Deutsche Gesellschaft for International Zusarnmenarbeit Gmbh-GermanInternational Corporation, India.

Ministry of Environment Forest & Climate Change (MoEF&CC), 2014. India Progress in Combating Climate Change. Briefing paper for UNFCCC, COP20, Lima, Peru.

National Bank for Agriculture and Rural Development(NABARD), 2015. Climate Change Project Development, NIE and Climate Change Vertical NABARD Head Office ,Mumbai.

South Asian Forum for Environment (SAFE), 2015. Climate Initiatives of SAFE.

The Indian Network on Climate Change (INCA), 2010. Climate Change and India : A 4×4 Assessment, A sectoral and regional analysis for 2030. Ministry of Environment, Forest & Climate Change, GoI.

Web References

http://ar5-syr.ipcc.ch
Climate Change 2014 Synthesis Report Fifth Assessment Report, IPCC

http://ccap.org
Centre for Clean Air Policy, USA

http://www.climate.be
Georges Lemaître Centre for Earth and Climate Research, Belgium

www.climatecentre.org
Red cross/Red Crescent: Climate Centre, Netherlands

http://climatechange.gc.ca
Climate change, Government of Canada

www.climatechangenationalforum.org
Climate Change National Forum : An Open National Dialogue on the Science of Climate Change and its policy implications, USA

www.climateprediction.net
Climate Prediction : The World Largest Climate Modelling experiment for the 21st century, UK

http://climate.nasa.gov
Global Climate Change: Vital Signs of the Planet, NASA

www.c2es.org
Centre for Climate and Energy Solutions: Working together for the Environment & the Economy

http://dfa.gov.au
Department of Foreign Affairs & Trade, Auatralia

www.ec.gc.ca
Environment and Climate Change Canada

www.ipcc.ch
Intergovernmental Panel on Climate change

www.justclimateaction.org
Just Climate Action, An Initiative of Ministry of Environment and Climate Change

www.moef.nic.in
Ministry of Environment, Forest & Climate Change

https://www.nasa.gov/
National Aeronautics and Space Administration

https://nas-sites.org
The National Academics of Sciences- Engineering – Medicine

http://www.nap.edu
The National Academic Press

www.noaa.gov
National Oceanic and Atmospheric Administration

www.ncdc.noaa.gov
National Centers for Environment Information, National Oceanic and Atmospheric Administration

www.pearsonhighered.com
Pearson Education, USA

www.ipcc.ch
Intergovernmental Panel on Climate change, Switzerland

www.realclimate.org
Real Climate: Climate Science from Climate Scientists

www.unep.org
United Nations Environmental Protection Agency

http://unfccc.int
United Nations Framework Convention for Climate Change

www.wmo.int
World Meteorological Organization

www.wri.org
World Resources Institute, USA

Other Useful Weblinks

www.carbonbrief.org
Carbon Brief : The Clear on Climate

http://www.cgdev.org
Climate Change: Mapping the Impacts of Climate Change, Europe

http://www.climatehotmap.org
Union of Concerned Scientists, Climate Hot Map, Global Warming Effects Around the World

http://climatenexus.org/
Climate Nexus, USA

http://www.globalchange.gov/
US Global Change Program

http://newsroom.unfccc.int/
United Nations Framework Convention on Climate Change

www.tyndall.ac.uk
Tyndall Centre for Climate research

http://worldviewofglobalwarming.org
World view of Global Warming, USA

Warming may delay next ice age

Global warming is likely to disrupt a natural cycle of ice ages and delay the onset of the next one until about 1,00,000 years from now, scientists said on Wednesday.

In the past million years, the world has had about 10 ice ages before swinging back to warmer conditions. In the last ice age that ended 12,000 years ago, ice sheets blanketed what is now Canada, northern Europe and Siberia.

In a new explanation for the long-lasting plunges in global temperatures that cause ice ages, scientists pointed to a combination of long-term shifts in the Earth's orbit around the sun, together with levels of carbon dioxide in the atmosphere. They said the planet seemed naturally on track to escape an ice age for the next 50,000 years, an unusually long period of warmth. But rising man-made greenhouse gas emissions since the Industrial Revolution could mean the balmy period will last for 100,000 years.

"Humans have the power to change the climate on geological timescales," said lead author Andrey Ganopolski. Another group of scientists suggested an "Anthropocene epoch" began in the mid-20th century with factors such as nuclear tests and industrialisation.

Hans Joachim Schellnhuber, another author, said a new epoch might instead be called the 'Deglacial'.

Source: January 15, 2016, The Times of India

India, France to work towards implementation of CoP21 goals

NEW DELHI: After successful conclusion of the Paris Climate Change summit, India and France today agreed to work towards the realization of the agreement's goals and carry out its implementation by collaborating in the field of sustainable development and energy.

Prime Minister Narendra Modi congratulated French President Francois Hollande for his "sustained" diplomatic efforts that paved way for adoption of the Paris agreement which was based on the principle of "climate justice" and fostering climate resilience and low greenhouse gas emissions development.

"The visit to India is the first foreign visit by President Hollande since the conclusion of COP21. Prime Minister Narendra Modi congratulated President Francois Hollande for France's valuable leadership and sustained diplomatic efforts that paved the way for the successful conclusion of COP21 in Paris in December 2015. "...and adoption of the Paris agreement, based on the principles of climate justice, and fostering climate resilience and low greenhouse gas emissions development," a joint statement by the two countries said.

The universal agreements, which were reached at Conference of Parties (CoP21), aims to keep the global temperature rise well below 2 degrees Celsius this century and to drive efforts to limit the temperature increase further to 1.5 degrees Celsius above pre-industrial levels.

President Hollande also thanked India and Modi for playing an "important and proactive" role in the negotiations.

In the wake of the Paris Agreement adopted at the end of the COP-21, the bilateral cooperation between France and India is today "more than ever" committed to meet the climate challenge, it said.

The two countries wish to carry out the implementation Paris agreement goals by promoting collaboration in sustainable development and energy between governments, regions, cities and also companies, the statement said.

The two countries wish to carry out the implementation Paris agreement goals by promoting collaboration in sustainable development and energy between governments, regions, cities and also companies, the statement said.

India had hailed as "historic" the adoption of a legally-binding pact in Paris but said the deal could have been more ambitious had developed nations shouldered more historical responsibilities.

Source: January 25, 2016, The Economic Times

Greenhouse gases fuelling long-term global warming

The Earth is known to be able to restore its temperature equilibrium after a period of natural warming. But the phenomenon tends to be overwhelmed locally by external drivers like greenhouse gases that can cause sustained changes in global temperature in the long run, a study has found.

Researchers at NASA's Jet Propulsion Laboratory in Pasadena, California, and Duke University in Durham, North Carolina, combined global climate models with satellite measurements of changes in the energy approaching and leaving the Earth at the top of the atmosphere over the past 15 years to study the human impacts on global temperatures in the long run.

The satellite data were from the Clouds and the Earth's Radiant Energy System (CERES) instruments on NASA's Aqua and Terra spacecraft. Scientists have long known that as the Earth warms, it is able to restore its temperature equilibrium through a phenomenon known as the Planck Response.

The phenomenon is an overall increase in infrared energy that the Earth emits as it warms. The response acts as a safety valve of sorts, allowing more of the accumulating heat to be released through the top of the Earth's atmosphere into space.

Source: February 9, 2016, The Times of India

India praised for Climate Change initiatives

Praising India's Climate Change initiatives in the run-up to the Paris summit, an eminent American expert has said the implementation of renewable energy targets has the potential to "drastically shift" global markets.

"The implementation of the renewable energy targets set as a part of the Paris Agreement by countries like India and China has the potential to drastically shift global markets," Andrew Steer, president and CEO of World Resources Institute, said during a Congressional hearing.

The ambitious goals set by PM Narendra Modi on solar energy is driven by economic development of the country, Steer told members of Committee on House Science, Space and Technology during a hearing on Paris Summit on Climate Change.

"China invested twice as much in solar capacity in 2015 as the United States, and is on track to become a superpower of the low-carbon economy. Indian Prime Minister Narendra Modi increased India's solar power capacity goal for 2030 from 20 GW to 175 GW," Steer said.

For comparison, the US has only about 25 gigawatts of solar capacity, he told the lawmakers.

"Prime Minister Modi didn't make this decision because he's a member of Greenpeace. He did it because it makes the most sense for India's economic development," Steer said.

At the same time as investment in renewables is surging, demand for high-polluting fuels such as coal is stalling globally and even declining in fast-growing economies like India, where imports dropped by 34 per cent in 2015, he said.

India's decision to increase its renewable electrical capacity to 40 per cent of total installed electrical capacity by 2030, builds on PM Modi's earlier commitment to increase solar power to 100 gigawatts by 2022 -- 30 times the current level and five times above the previous renewable energy target, he added.

This renewable energy target will require aggressive domestic action, as it significantly exceeds current policy scenario projections notable, given India's per capita emissions are only one-third of the global average, he said.

"India is continuing to rapidly decrease the cost of solar, with a further seven per cent reduction in tariffs this year. The total installed cost for solar in India dropped by more than 20 per cent in 2015 alone," Steer said.

Testifying before the committee, Vice president of US

Chamber of Commerce, Stephen Eule said that India, which is one of the world's biggest geeenhouse gas (GHG) emitters, has committed to reducing its GHG emissions intensity by 33 per cent to 35 per cent between 2005 and the 2030s, about one third of which was met by 2010.

"We estimate that if it meets this goal, its emissions will grow from about 3 billion TCO2 in 2010 to about 5 to 6 billion TCO2 in 2030 at jump of at least 80 per cent.

Importantly, India's INDC is conditional on financial and technology assistance that it estimates could run to USD 2.5 trillion out to 2050," Eule said.

In the meantime, he said, India announced that it intends to double domestic coal output over the next five years to fuel economic expansion.

Source: February 3, 2016, Business Standard

India to sign Paris Climate Change agreement on April 22

On April 22, India will formally sign the Paris climate agreement, adopted by over 190 countries last year December.

The agreement will be open for signature at the United Nations headquarters in New York for one year, from April 22, 2016 to April 21, 2017. Around 80 to 100 countries are likely to sign the agreement on the first day itself.

The country's environment, forests and Climate Change minister Prakash Javadekar will represent India at the signing event, called by the UN Secretary-General Ban Ki-moon.

"India has communicated to the UN agency about signing the agreement. The government has authorised Javadekar for formally signing the Paris climate deal which will come into effect in 2020," said an official, adding the country will also ratify it as early as possible.

Under Article 21 of the agreement that was adopted on December 12 last year in Paris, after a marathon negotiation lasting 13 days, at least 55 countries accounting for an estimated 55 per cent of the total global greenhouse gas emissions will have to ratify\accept\approve the agreement before it enters into force.

The Article 21 says that the Paris agreement will enter into force on the 30th day after the date on which at least 55 parties to the United Nations Framework Convention on Climate Change (UNFCCC) deposit their "instruments of ratification, acceptance, approval or accession" with the depositary at UN headquarters.

So far, three countries - Fiji, Palau and Marshal Islands - have completed their ratification process. These three highly vulnerable Pacific island nations are expected to submit their instruments of ratification after the signature ceremony next month.

The Paris deal is the most ambitious Climate Change agreement in history. It established a long term, durable global framework to reduce global greenhouse gas emissions where 195 countries will work together to put the world on a path to keeping global temperature rise well below 2 degrees Celsius and agree to pursue efforts to limit the increase in temperatures to 1.5 degrees Celsius.

All the countries have, for the first time, committed to put forward successive and ambitious 'nationally determined' climate targets and report on their progress, using a rigorous and standardized process of review.

Source: Mar 25, 2016, The Economic Times

Climate Change: Melting Antarctic ice sheet could cause 15m sea level rise

Melting of the Antarctic Ice Sheet could cause sea level to rise by twice as much as previous thought. Scientists say updated models show melting could contribute more than one metre in sea level rise by 2100.

The research published in Nature is the first to successfully use sea level records from the Pliocene (around three million years ago) to project future sea level rise. They say that melt from the Antarctic Ice Sheet could contribute more than a one metre rise in sea level by 2100, and a 15m rise by 2500.

During the last Interglacial period (130,000 years ago), sea levels were six to nine metres higher than they are today. During

the Pliocene, they were even higher. In these time periods, the average global temperature was only slightly warmer than it is today.

"Recently we looked at the long-standing problem posed by geological evidence that suggests sea level rose dramatically in the past, possibly up to 10 to 20 meters in the Pliocene," said David Pollard, co-author of the study. "Existing models couldn't simulate enough ice sheet melting to explain that."

Researchers used historical data from the Pliocene to model future climate scenarios. They used this to find the ice shelves are more sensitive to climate than previously believed, which caused large melting in the past.

Sea level could rise by 1m by 2100 due to Antarctic ice loss

They also added two new mechanisms into their model, which haven't been used in projections before. The first was enhanced fracturing of low-level ice which allows more ocean water to infiltrate, leading to more melting. The second mechanism suggests ice fragments break off and cause giant walls of ice, which cannot support their own weight and crash into the ocean.

After adding in these mechanisms, the researchers found sea level could rise by one metre by 2100. In addition, this could rise to 15 metres by 2500 if greenhouse gas emissions continue at its current rate.

In the scenario they modelled, the researchers say the main driver of ice loss will become the warming atmosphere, as opposed to the warm ocean. However, the rapidly warming ocean will then delay ice sheet recovery for thousands of years.

"This could spell disaster for many low-lying cities," said Robert DeConto, who worked on the study. The researchers emphasise that the model is a worst-case scenario, however, adding it can still be delayed by reducing greenhouse gas emissions.

"Although the future sea-level contribution in our model is greater than previously thought, it is based on credible mechanisms and is consistent with geologic evidence of past sea-level rise," said Pollard. "We regard the results as worst-case envelopes of possible future behaviour, and the mechanisms should be considered seriously in future work."

Source: March 30, 2016, International Business Times

Asia: One billion people to face severe water shortages by 2050

Countries in Asia will face severe water shortages by 2050 if current environmental, demographic and economic trends remain unchanged. This is the conclusion that MIT scientists have reached, after running different simulations of future climatic scenarios in the region.

Published in the journal PLOS One, their study points out that water shortages are not simply the results of Climate Change and environmental stress. Other factors should be taken into account, if people are to have the best possible access to the precious natural resource.

"It's not just a Climate Change issue," co-author Adam Schlosser emphasises. "We simply cannot ignore that economic and population growth in society can have a very strong influence on our demand for resources and how we manage them. And climate, on top of that, can lead to substantial magnifications to those stresses."

The extent of the damages in Asia could indeed be very important. The scientists find that median amounts of projected growth and Climate Change in the next 35 years would lead to roughly 1 billion more people becoming "water-stressed", compared to today.

Different possible scenarios

To better understand how population growth and economic development interact with Climate Change, leading to water stress, the scientists used a model previously developed by the MIT, the Integrated Global Systems Model (IGSM).

The IGSM is based on projections of population growth, economic expansion, climate, and carbon emissions due to human activity. Keeping some variables constant, the scientists looked at different possible scenarios for 2050, in different Asian nations, including India and China.

They called one of their proposed scenarios the 'Just Growth' model, because they held climatic conditions constant and only evaluated the effects of economic and population growth. In the 'Just Climate' model, the researchers reversed the experiment, keeping growth constant. Finally, a model called 'Climate and Growth' completed the research, by looking at the impact of all factors taken together.

"This model gave us a unique ability to tease out the human and environmental factors leading to water shortages and to assess their relative significance", Schlosser says. He points out that a combination of all these factors can lead to the most severe water shortages, impacting millions of people.

Particularities between countries

The IGSM model allows researchers to look at how, under the same variables, scenarios change according to countries. This is particularly useful to come up with country-specific strategies, in order to avoid water stress.

"For China, it looks like industrial growth [has the greatest impact] as people get wealthier," lead author Charle Fant explains. "In India, population growth has a huge effect. It varies by region."

Study's authors say other variables should be examined, such as water supply networks into and out of the different areas, and the way population is distributed around said supplies. Further research by the team will also investigate to what extent changing water-use practices can have.

"We are assessing the extent to which climate mitigation and adaptation practices – such as more efficient irrigation technologies – can reduce the future risk of nations under high water stress," Schlosser concludes.

Source: March 30, 2016, International Business Times